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THESIS

**TACTICAL FIREFIGHTER TEAMS: PIVOTING
TOWARD THE FIRE SERVICE'S EVOLVING
HOMELAND SECURITY MISSION**

by

Cynthia M. Vargas

September 2016

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**TACTICAL FIREFIGHTER TEAMS: PIVOTING TOWARD THE FIRE
SERVICE'S EVOLVING HOMELAND SECURITY MISSION**

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ABSTRACT

Firefighters and police officers are increasingly called upon to work in each other's spaces but are neither trained nor equipped to do so; consequently, they are limited in their ability to enter one another's high threat areas. Fire complicates the police's ability to respond to hostile incidents by creating visibility issues and thermal injuries as the burning building deteriorates. Firefighters are equally ill-prepared to enter an environment in which fire and firearms are present while victims are trapped within the hazard zone. As a result, first responders consistently lack the capability to accomplish combined missions when multiple threats are present. This thesis investigates the best way to fill this operational gap, first by examining the merits and limitations of several models related to the role of firefighters during hostile events. It then documents and analyzes the field tests of a fourth model piloted by the Houston Fire Department that would deploy cross-trained firefighting strike teams into hot zones with both incendiary and ballistic hazards.

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LIST OF ACRONYMS AND ABBREVIATIONS

BTHP	boat tail hollow point
CBRNE	chemical, biological, radiological, nuclear and explosives
CEU	civil emergency unit
CFD	Charlotte Fire Department
CMPD	Charlotte-Mecklenburg Police Department
CONTOMS	counter narcotics tactical operations medical support
CRC	critical response command
C-TECC	Committee on Tactical Emergency Casualty Care
EMS	emergency medical services
EMT	emergency medical technician
ESU	emergency service unit
FBI	Federal Bureau of Investigation
FDNY	Fire Department of the City of New York
FEMA	Federal Emergency Management Association
HazMat	hazardous materials
Haz-Tac	hazardous materials tactical
HFD	Houston Fire Department
HPD	Houston Police Department
HVAC	heating, ventilation, and air conditioning
IAB	InterAgency Board
IAFC	International Association of Fire Chiefs
IAFF	International Association of Firefighters
IARD	immediate action rapid deployment
IDLH	immediately dangerous to life and health
IED	improvised explosive device
ITRT	integrated tactical response teams
LeT	Lashkar-e-Taiba
LFRA	Loveland Fire Rescue Authority
NFPA	National Fire Protection Association
NIJ	National Institute of Justice

NIST	National Institute of Standards and Technology
NYPD	New York Police Department
OSHA	Occupational Safety and Health Administration
PAC	police assist company
PASS	personal alert safety system
PPE	personal protective equipment
RTF	rescue task force
SCBA	self-contained breathing apparatus
SRG	strategic response group
SWARM	syndicated, water-enabled, anti-siege response matrix
SWAT	special weapons and tactics
TECC	tactical emergency casualty care
TEMS	tactical emergency medical support
TIC	thermal imaging camera
TPIA	Texas Public Information Act
TPP	thermal protection performance
USAR	urban search and rescue

EXECUTIVE SUMMARY

Worldwide, terrorist attacks are becoming more tactically complex through the implementation of multiple attack modalities. To address the changing threat environment, first responders must actively consider alternative strategies to asymmetric attacks and acknowledge the need to place firefighters within a combined law enforcement and firefighter hot zone. While it is not yet common for fire to be effectively deployed by assailants to confuse and delay access to hostages and victims, public safety personnel need to be prepared to respond when fire is used as a weapon during a hostile event.

This thesis examined the need for and utilization of tactical firefighter teams in the U.S. fire service to assist law enforcement during hostile events requiring combined fire and police skill sets to mitigate the incident. However, a significant limitation of the models involves the lack of inter-disciplinary use of protective equipment, which results in the inability of the responders to enter each other's threat spaces safely. Therefore, while diverse skill sets are present in integrated teams, integrated equipment that would be appropriate to enter a multi-threat environment is lacking.

Complex, multifaceted threats require not only a cross-disciplinary incident response by first responders, but also require the first responder to be equipped across disciplines. To address these gaps, the Houston Fire Department (HFD) has explored ways of introducing fire personnel into areas of direct threat by field testing adaptations to the protection ensembles worn by firefighters and police officers. Their findings support the concept of combining ballistic vests with structural firefighting bunker gear to engage in interior fire suppression during hostile events. The HFD model also proposed combining law enforcement rapid deployment tactics with firefighting tactics and the introduction of armed public safety personnel into areas where fire and smoke are present. This thesis evaluated HFD's experimental efforts as they progress toward the implementation of their pilot program and synthesized Houston's findings with lessons learned from other jurisdictions. This thesis recommended the implementation of a tiered deployment model for tactical fire teams responding to hostile events and proposed the

use of cross-trained firefighting strike teams trained and equipped to enter into hot zones in which incendiary and ballistic hazards are simultaneously deployed. The following recommendations for the implementation of tactical fire teams were made.

Develop Rescue Task Force capabilities for all Emergency Response Personnel: The rescue task force model implemented by the Fire Department of the City of New York ensures rapid response to hostile events during the earliest stages. These units provide a large pool of personnel for less tactically complex tasks that still require firefighting skill sets. By combining with available police officers, these teams can provide fire, rescue, and emergency medical services support within warm zones.

Incorporate Charlotte Fire Department's and Loveland Fire Rescue Authority's models to assist law enforcement personnel: Researchers have demonstrated that tactically complex tasks and complex motor skills require repetitive training to ingrain movement into the motor memory when under extreme stress.¹ Chaotic unstable environments can increase stress reactions that further contribute to the obstacles the operators must overcome. Designate specific personnel at fire stations to receive tactical training for incorporation into SWAT teams to support breaching activities, chemical, biological, radiological, nuclear and explosives response, and gross decontamination during hostile events to include instances of civil unrest. Although these teams will be limited to warm zone operation, they will serve as a force multiplier especially when multiple venues are involved and resources will be spread throughout the area.

Develop Special Operations Team for Response to Hostile Events: This thesis builds on existing tactical fire team models and offers an additional solution that takes advantage of the HFD's arson investigation division. With experience in fighting fire and experience as law enforcement officers, members of the arson unit are uniquely situated to respond as either a strike team capable of fire suppression, law enforcement rapid deployment to neutralize armed assault, or as a force multiplier to augment the efforts of existing rescue task forces during hostile events. However, responding to hostile events

¹ Richard A. Schmidt and Craig A. Wrisberg, *Motor Learning and Performance: A Situation-Based Learning Approach*, 4th ed. (Champaign, IL: Human Kinetics, 2008), 7.

will require advanced skill sets with operators who can improvise when tactics or equipment fail. First units to enter must be autonomous and cross-disciplined since unknown threats can be encountered. The role of this special operations team would be to disentangle the threats sufficiently to allow traditional firefighting units to continue extinguishing the fire and traditional law enforcement units to continue searching for assailants.

The tactical firefighter model is not to be viewed as a panacea but as an additional resource for the fire department in the event of a paramilitary attack. Sean Newman's research demonstrated that "what is consistently absent from law enforcement preparations for a Mumbai-type terrorist event is the consideration of fire as part of the weapons mix."² This same lack of preparation is evident on the fire department side as well. By failing to consider the possibility of this type of assault, the responsibility of developing response strategies is left to the on-duty personnel who have little or no preparation to meet the demands of a rapidly unfolding paramilitary attack. The recommendation to deploy arson squad assets to terrorist attacks increases the capability of the HFD by providing additional skill sets from a workforce that has not historically been used in an emergency response setting. While it is not feasible to anticipate and develop responses to every single crisis, it is possible to increase the department's capabilities to allow for greater adaptability in the midst of chaotic events.

² Sean Newman, "Braving the Swarm: Lowering Anticipated Group Bias in Integrated Fire/Police Units Facing Paramilitary Terrorism" (master's thesis, Naval Postgraduate School, 2011), 37.

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I. INTRODUCTION

A. RESEARCH QUESTION

This thesis addresses one question: What is the best way to implement tactical firefighter teams?

B. PROBLEM STATEMENT

Firefighters and police officers are increasingly called upon to work in each other's spaces but are not trained nor equipped to do so; as a result, they are limited in their ability to enter one another's high threat areas. During low-frequency, high-consequence hostile events, this limitation can lead to delayed assistance to the public. In addition to the projectile and improvised explosive device (IED) hazards law enforcement may encounter when pursuing an assailant, fire complicates the police's ability to respond by creating visibility issues, toxic fumes, thermal injuries from heat exposure, and blunt force trauma due to falling debris as the burning building deteriorates.¹ Firefighters are equally ill-prepared to enter an environment in which fire and firearms are present while victims are trapped within the hazard zone. In general, first responders lack a cross-disciplined entry team to accomplish combined missions that challenge traditional, single-discipline response paradigms.

Some early attempts have been made at developing tactical fire units to support law enforcement by embedding firefighters within SWAT or by creating ad hoc multidisciplinary teams.² Much like tactical medics, these tactical firefighter teams attempt to fill operational gaps during complex, hostile events when a multidisciplinary approach is required to save lives. However, a major limitation of early tactical firefighter models is their reliance on the presence of SWAT teams for the deployment of fire assets;

¹ *Subcommittee Hearing: Protecting the Homeland Against Mumbai-Style Attacks and the Threat from Lashkar-E-Taiba Counterterrorism and Intelligence Subcommittee Counterterrorism* (2013) (Statement by Assistant Chief Joseph W. Pfeifer Chief of Counterterrorism and Emergency Preparedness Fire Department of the City of New York).

² "Tactical Fire Team," accessed March 17, 2016, <http://www.cityofloveland.org/index.aspx?page=1864>.

they do not attempt interior attacks to suppress fire, even with victims trapped inside, until and unless SWAT or law enforcement arrives.³

The reliance on the presence of SWAT is inadequate to mitigate cross-disciplinary threat environments with fire present. This inadequacy can prove problematic in situations in which the SWAT team has an extended response time; not all SWAT teams operate on a 24/7 basis. When incidents occur outside of the team's regular working hours, SWAT arrival can be delayed for over an hour.⁴ Given the heavy use of synthetic furnishings within households today, a fire could easily progress to full structural involvement in less than five minutes, leaving little chance for survivors by the time SWAT arrives.⁵ Furthermore, most SWAT teams do not have an unlimited number of members; in the event that SWAT is committed at a different incident, insufficient SWAT personnel could be available to support the latest emergency.

In today's public safety sphere, budgets are tighter and missions are broader. As incidents have become more complex, collaboration and cross-training across police and fire roles is becoming compulsory. Some agencies have combined firefighters and police officers to create teams, but members are limited to the areas within which they are able to operate.⁶ The Loveland (Colorado) Fire Rescue Authority, the Charlotte Fire Department (CFD), and the Fire Department of the City of New York (FDNY) have implemented different models of tactical fire teams to support law enforcement operations. However, a significant limitation of the models involves the lack of interdisciplinary use of protective equipment, which results in the inability of the responders

³ Loveland Fire Rescue Authority, *General Operations Policy: Tactical Fire Team Operational Policy* (Loveland, CO: Loveland Fire Rescue Authority, 2012), 1.

⁴ John P. Giduck and Walter D. Chi, *An Evaluation and Assessment of the Law Enforcement Tactical Response to the Virginia Tech University Shootings of Monday, 16 April 2007* (Golden, CO: Archangel Group, LTD., 2008), 108.

⁵ Underwriters Laboratory, "Modern Residential Fires," *New Science Fire Safety Journal* no. 1, 5, accessed May 30, 2016, http://newscience.ul.com/wp-content/uploads/2014/04/NS_FS_Journal_Issue_1.pdf. According to Underwriters Laboratory studies of modern fire progression, full room involvement can occur within five minutes.

⁶ FDNY Center for Terrorism and Disaster Preparedness with International Partners, *Interagency Tactical Response Model: Integrating Fire and EMS with Law Enforcement to Mitigate Mumbai-Style Terrorist Attacks* (New York: FDNY Center for Terrorism and Disaster Preparedness with International Partners, 2012), 4–7; Charlotte Fire Department, *Tactical Operating Guideline: Active Violence Incident* (Charlotte, NC: Charlotte Fire Department, 2014).

to enter each other's threat spaces safely. Therefore, while diverse skill sets are present in integrated teams, integrated equipment that would be appropriate to enter a multi-threat environment is lacking.

To address this gap, in 2015, the Houston Fire Department (HFD) began pilot testing a group of cross-trained and cross-equipped arson investigators to enter law enforcement and firefighter high threat areas in the absence of a SWAT or police department escort.⁷ The Houston pilot program is different than previous models, in that it challenges the boundaries of previous units by introducing armed firefighter strike teams into the hot zone who are capable of suppressing the fire and engaging active assailants.

One of the challenges in conducting the research for this thesis involved the lack of published after action reports regarding the implementation of firefighter teams within a tactical, law enforcement environment. Within the fire service, formal evaluation for program effectiveness is not a customary practice outside of graduate research; generally, fire departments only produce after action reports following significant incidents to capture lessons learned. The results of the Houston tests are described and evaluated in this thesis with the purpose of using it as the basis to propose a new template for cross-disciplined tactical first responder teams.

C. METHOD AND DESIGN

This thesis is a study of tactical firefighter teams in the United States. It describes and evaluates existing and emerging teams, in particular, the development and the equipment field testing of the most self-sufficient team to date, that of the Houston Fire Department's, which attempts to pick up where other jurisdictions have left off. In 2015, the HFD program began as a series of field tests in an attempt to use a formalized methodology to assess the value and feasibility of creating a tactical firefighter program before committing substantial resources. This type of research provides a way for

⁷ Houston Fire Department, internal memo, August 3, 2015.

products and services to transition from idea to implementation in a more cost effective and efficacious manner by allowing for experimentation and shifts in strategy.⁸

This thesis evaluates HFD's experimental efforts as they progress toward the implementation of their pilot program and synthesizes Houston's findings with lessons learned from other jurisdictions to offer recommendations for a new model. The field-testing discussed was conducted during the regular course of my duties. Although the results have not yet been published by the HFD, written permission was obtained from the department head to release the findings and field notes for the purpose of this study.⁹ When applicable, reference is made to original field notes and memos. In their absence, the author will report the findings herself since she conducted the testing as part of her employment with HFD. While this thesis reports HFD's findings, it does not serve as HFD's sole vehicle for reporting the findings of their program. Instead, this thesis seeks to prove the value of tactical fire teams as a new core fire service capability.

D. SIGNIFICANCE

This thesis contributes to the existing research by offering recommendations on how a tactical team should be implemented. The HFD model picks up from earlier models and goes further in that it does not rely on linking up with SWAT nor does it rely on an external law enforcement escort for firefighter entry into a multi-hazard environment. Ultimately, it will build on previous practices by combining methods and makes recommendations toward policy steps with the goal of creating a national-scale use of this model.

E. LIMITATIONS

At the onset of this research, the author made a deliberate decision to use only written documentation exclusively and not to rely on surveys and interviews. In retrospect, that decision created substantial challenges in obtaining information since so much of the available information has not been captured in departmental reports. The

⁸ Deborah J. Bowen et al., "How We Design Feasibility Studies," *American Journal of Preventive Medicine* 36, no. 5 (2009): 452–457, doi:10.1016/j.amepre.2009.02.002.

⁹ The unpublished notes and memos are available via an open records request to the department.

ability to interview industry experts could have provided a more complete picture of the thought processes and implementation challenges that rarely make it into reports. While the available reports provided *what* decisions were made by specific departments, the context for those decisions was not recorded in any of the available documents. Therefore, it is known what their programs looked like, but not why they were shaped in the manner that they were. Future researchers should consider incorporation of surveys and interviews of industry leaders who have implemented tactical fire teams to provide a more complete picture of the process and to offer valuable insight to the obstacles faced by other departments as they formed their programs.

F. THESIS ORGANIZATION

This thesis is divided into six chapters. The first chapter identifies the scope and purpose of the research, and summarizes the design and significance of the thesis. Chapter II discusses the literature and provides context for the research conducted. Chapter III describes the vision and concept for tactical fire teams with a description of early models for tactical fire teams in the United States. Chapter IV analyzes the protective equipment needs for a tactical fire team. Chapter V discusses and evaluates the HFD's field studies in their development of a tactical fire team. Chapter VI consists of recommendations and conclusions.

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II. BACKGROUND

A. INTRODUCTION

Historical events have revealed the inadequacies of the American fire service's "stage and wait" response paradigm during hostile events in which firefighters and police officers must coordinate their responses.¹⁰ In addition to law enforcement's mission of neutralizing the assailants, several traditional fire and EMS activities must often occur simultaneously to successfully mitigate the threat. Although rare, activities, such as breaching, fire suppression, rescues, and medical services at the point of wounding, may be required by the initial responders within areas of gunfire or direct threat. This chapter discusses the role of tactical medics and rescue task forces, identifies the limitations of current strategies used by firefighters for rescue and response to an unstable hostile environment, and advocates for the need to adapt to dynamic threats further.

The American fire service was originally developed to protect people and their property from fires.¹¹ Since its colonial beginnings, the service has maintained its core mission of protecting life and property but has adopted and expanded its capabilities to the needs of the community it serves. It has become increasingly the norm during the last 50 years as modernization and industrialization have led to larger, denser urban areas. In addition to fighting fires, core services performed by firefighters now include emergency medical services, hazardous materials response, technical rescue, and response to civil unrest and terrorist incidents. The fire service continues to face an ever-changing threat environment and must regularly adapt its strategies to protect life and property within dynamic incidents at much earlier stages than previously practiced. Emergencies that in their early stages historically focused on response by law enforcement increasingly

¹⁰ State of Colorado, *The Report of Governor Bill Owens' Columbine Review Commission* (State of Colorado, 2001), 23.

¹¹ Paul C. Ditzel, *Fire Engines, Fire Fighters: The Men, Equipment, and Machines, From Colonial Days to the Present* (New York: Bonanza Books, distributed by Crown Publishers, 1984).

require a coordinated response by police, fire, and emergency medical services (EMS) providers.¹²

Worldwide, events—particularly those with a terrorist nexus—are becoming more tactically complex. Hostile events like the ones that occurred in Mumbai, Paris, and Orlando demonstrate the need for emergency responders to review their strategies periodically and make modifications. During the last five decades, firefighters have increasingly responded to terrorist incidents; however, as a whole, the American fire service has been slow to incorporate new strategies to those evolving threats.¹³ Since the 9/11 attacks, fire departments can no longer ignore that response to terrorist assaults, and hostile events are the new normal and have become a core service for firefighters. Whether the assault is internationally or domestically motivated matters little to the American public; the community and elected officials expect their fire departments to take calculated risks to fulfill their primary mission of saving lives.¹⁴

B. LITERATURE REVIEW

The purpose of this review is to examine the available literature regarding the fire service's tactical role during incidents in which a combined police and fire multidisciplinary approach would expedite first responder mission objectives of increasing the survivability for hostages and victims. Aside from graduate research, little relevant scholarly literature pertains to the role of firefighters in support of law enforcement activities during tactical operations involving suppression activities; most of the existing research focuses on the medical response. Noticeably absent from the literature is a review of active threats requiring fire suppression in the midst of an armed assault. This literature review examines the past, present, and future roles of firefighters in support of law enforcement tactical incidents.

¹² Department of Homeland Security, *First Responder Guide for Improving Survivability in Improvised Explosive Device and/or Active Shooter Incidents* (Washington, DC: Office of Health Affairs, 2015), 15.

¹³ Michael Marino et al., "To Save Lives and Property: High Threat Response," *Homeland Security Affairs* 11, 2015, <http://search.proquest.com/openview/59c10615170ebaa4dd95ad312309910e/1?pq-origsite=gscholar>.

¹⁴ *Ibid.*

1. Traditional Fire Service Role

Since the 1999 mass killing at Columbine High School, various federal agencies have published guidance suggesting first responder disciplines (fire, EMS, and police) work more closely together during mass shootings and terrorist attacks.¹⁵ Fire service practitioners have been slow to operationalize the vague recommendations.¹⁶ Since 2010, a growing body of literature, produced by first responders, has advocated for the formation of multidisciplinary task forces that combine the capabilities of firefighters, EMS personnel, and police officers to rescue injured victims. One of the most important works to date was authored by a group of experts within the medical, EMS, and fire communities. According to Marino et al., public outcry following the tragedy at Columbine High School caused a paradigm shift for law enforcement agencies but did not result in strategic changes for firefighters and EMS.¹⁷ The authors contend that before that event, police officers responding to hostage crises, shootings, and terrorist events employed a set of protocols known as the five “Cs”: “contain, control, communicate, call SWAT, and create a plan.”¹⁸ The authors further assert that although law enforcement altered its long-standing tactics in favor of aggressively pursuing the shooter, the fire service did not change its traditional “stage and wait” model, with most fire departments continuing to maintain this protocol.¹⁹ As a result, firefighters place their own safety above the needs and expectations of the public they are sworn to serve by staging at a safe distance until the police provide assurance that the scene is completely safe.²⁰ To adapt to the dynamic threat environment increasingly encountered by first responders, the authors proposed the formation of integrated medical response teams composed of firefighters, EMTs and police officers to rescue injured victims while law enforcement contact teams pursue and eliminate the shooter. Although their

¹⁵ United States Fire Administration and Tridata Corporation, *Wanton Violence at Columbine High School, April 20, 1999: Special Report* (Washington, DC: Federal Emergency Management Agency, 1999), 35, <https://books.google.com/books?id=AFecjgEACAAJ>.

¹⁶ Marino et al., “To Save Lives and Property: High Threat Response.”

¹⁷ Ibid.

¹⁸ Ibid.

¹⁹ Ibid.

²⁰ Ibid.

recommended guidelines are rooted in successful military battlefield principles, the authors acknowledged several reasons the fire service has failed to institutionalize an integrated medical response model to high-casualty, high-threat incidents involving firearms: firefighter perception that the incident is exclusively law enforcement's responsibility, firefighter attitude toward acceptable risk, and the historical mission of the fire service. The most salient characteristic of the work is that it addresses and counters many of the common arguments posed by fire and EMS personnel who resist the rescue task force model as a new fire service core capability during mass casualty incidents. Scholarly writing providing a counter-argument to Marino et al. is nonexistent. Dissent to their proposal can be measured via the overwhelming lack of implementation throughout the nation's fire departments of the framework they propose.

2. Firefighters as Medical Rescue Task Forces and Tactical Medics

A significant portion of the literature discusses the role of firefighters as pre-hospital care rescuers. This position has been accepted by the International Association of Fire Chiefs (IAFC) and the International Association of Firefighters (IAFF) as a core fire service capability.²¹ Since the creation of SWAT teams in the 1960s, major urban fire departments have incorporated paramedics and EMTs within the police's SWAT team to support tactical operations. The earliest version of SWAT medics was among law enforcement personnel who were trained in trauma care. While some SWAT units continue to prefer this model, alternative iterations have emerged to incorporate experienced emergency medical services personnel with supplemental training in tactical team movement.²² Regardless of the route by which the medics were trained, their primary mission remains the same, to care for injured SWAT members.²³ However, the SWAT medic model was never intended for the care of mass casualties resulting from

²¹ International Association of Firefighters, *IAFF Position Statement: Active Shooter Events* (Fairfax, VA: International Association of Firefighters, 2013), http://www.iaff.org/Comm/PDFs/IAFF_Active_Shooter_Position_Statement.pdf.

²² National Tactical Officers Association, *Tactical Response and Operations Standard for Law Enforcement Agencies* (Doylestown, PA: National Tactical Officers Association, 2015), 25.

²³ Marino et al., "To Save Lives and Property: High Threat Response."

active shooters or terrorist attacks. Following several mass shootings with high injury counts, the concept of the rescue task force emerged.²⁴

The most comprehensive document to date recommending rescue task forces was published by the Department of Homeland Security.²⁵ The document recommends the formation of rescue task forces composed of firefighters and police officers to rescue as many victims as possible before the police have completely secured and searched the building.²⁶ Although not statutorily required, federal guidance clearly advocates for the introduction of firefighters into an area traditionally considered off limits to non-law enforcement personnel to maximize the likelihood that victims will survive a mass casualty or terrorist event.²⁷ The ideas presented in the document have been previously proposed by various industry experts during the last five years; however, this document consolidates many of the recommendations to a single comprehensive source.

While no scholarly literature per se exists on the use of armed tactical medics outside of the military environment, the literature does describe a few notable civilian fire departments and EMS agencies that have adopted a practice that might be considered a precedent for using armed firefighter teams within the hot zone traditionally restricted to law enforcement officers. A 2010 Fire-Rescue International Conference lecture by Sheriff K. Kimbrough and Battalion Chief B. Lowe describes a successful multidisciplinary program in which firefighters from Clayton County Fire and Emergency Services in Georgia support the SWAT team and seems to make the first argument for this kind of role among firefighter paramedics.²⁸ They reported that Clayton County's SWAT team was best served by cross-training firefighter and paramedics as police officers and cited several incidents in which the armed firefighter-medic was

²⁴ E. Reed Smith, Blake Iselin, and W. Sean McKay, "Toward the Sound of Shooting: Arlington, VA, Rescue Task Force Represents a New Medical Response Model to Active Shooter Incidents," *Journal of Emergency Medical Services* 34, no. 12 (2009): 49–55.

²⁵ Department of Homeland Security, *First Responder Guide for Improving Survivability in Improvised Explosive Device and/or Active Shooter Incidents*.

²⁶ *Ibid.*, 15.

²⁷ *Ibid.*, 19.

²⁸ Kem Kimbrough and Bill Lowe, "Armed and Deputized Tactical Medics," presentation at the Fire-Rescue International Conference, Chicago, IL: August 24–28, 2010.

necessary to the success of the mission.²⁹ Clayton County tactical medics are embedded with the entry team and provide care under fire to local police, sheriffs, and U.S. Marshals upon request from law enforcement. The medics routinely train to perform within the technically complicated, high-risk environment encountered by tactical officers, such as “low light conditions and chaotic scenes contributing to sensory overload.”³⁰ The medics are also equipped with traditional law enforcement gear, ballistic vests and firearms. Another innovation in the tactical medic model used in Clayton County was the ability of the firefighter and medics to respond to exterior structure fires for suppression duties when escorted by special weapons and tactics (SWAT).³¹ It is important because it fills an operational gap in which firefighting skills within a police incident are required; however, the authors reported the tactical medics are limited in their ability to enter a burning structure since the police cannot protect them inside the burning structure. For non-fire related emergencies, the medics are required to wear and deploy their firearm if needed to protect themselves or their patients.³²

Although the practice of providing care under fire has not gained widespread national support, a 2010 article in *Fire Chief* magazine reported a similar type of tactical medic program in Palm Bay, Florida in which firefighter paramedics are cross-trained as medical support for SWAT members.³³ According to the article, the medics are trained and certified as auxiliary police officers able to enter into the police hot zone to assist injured victims and seem to support the program created in Clayton County, Georgia.³⁴ The firefighters assist with breaching and rescue of patients, but cannot enter to extinguish a fire because of law enforcement’s inability to provide force protection in a heated environment.

²⁹ Kimbrough and Lowe, “Armed and Deputized Tactical Medics.”

³⁰ Ibid.

³¹ Ibid.

³² Ibid.

³³ Mary Rose Roberts, “On the Front Line,” *Fire Chief*, August 1, 2010, <http://firechief.com/ems/paramedic-cross-training-201008/>.

³⁴ Ibid.

The framework upon which these and other tactical medical response programs are based was developed by a group of trauma care experts known as the Committee on Tactical Emergency Casualty Care (C-TECC). In a 2011 article, members of the C-TECC described a three-tiered medical response at high threat incidents.³⁵ According to Callaway et al., the riskiest tactical response occurs during the first-tier, direct threat, or “care under fire.”³⁶ While the authors would not require firefighters and EMS providers to provide rescue during an armed assault, they specifically state that it is a possibility that can be considered under certain extreme circumstances.³⁷ It is a new concept and not accepted by labor organizations within the fire service, such as the IAFC, which support limited entry into a police environment, the warm zone, yet not in areas with direct threat, known as the hot zone.³⁸ The authors assert that “C-TECC guidelines provide an operational cost benefit model that allows all first responder practitioners with a means to balance the risk of intervention against the benefit of rescue.”³⁹ The article focuses on the appropriate level of medical intervention during hostile events and does not discuss the arming of medics or firefighters one way or the other.

A recurring theme of the literature is that in the absence of a SWAT or law enforcement escort, firefighting units should not attempt to suppress the fire or respond to injured victims. Much like the tactical medic, the tactical firefighter teams described are an attempt to fill operational gaps in the midst of complex hostile incidents where a

³⁵ David Callaway et al., “Tactical Emergency Casualty Care: Guidelines for the Provision of Pre-Hospital Trauma Care in High Threat Environments,” *Journal of Special Operations Medicine* 11, no. 3, (2011): 106.

³⁶ Ibid.

³⁷ Ibid., 104–122.

³⁸ Fire Department of the City of New York, *Interagency Tactical Response Model: Integrating Fire and EMS with Law Enforcement to Mitigate Mumbai-Style Terrorist Attacks*, 2; International Association of Firefighters, *IAFF Position Statement: Active Shooter Events*. The development of the concept of hazard zones arose out of a hazardous material response. Zones help operators define areas of risk, and are helpful for the traditional fire and rescue response. Threat designations for terrorist incidents are categorized as hot, warm, and cold zones, “A hot zone is an area where terrorists, or other actors are present, either roaming free or engaged by law enforcement. IED’s may be present. No fire suppression personnel or emergency medical service personnel are permitted to operate in areas designated as hot zones. The warm zone is an area that has been cleared by law enforcement with no identifiable suspects or improvised explosive device threats. The cold zone is the area that law enforcement has confirmed as free of threats.”

³⁹ Callaway et al., “Tactical Emergency Casualty Care: Guidelines for the Provision of Pre-Hospital Trauma Care in High Threat Environments,” 113.

multidisciplinary approach is required to save lives. Although criticism of the tactical firefighter paradigm does not appear in the literature, a lack of support is also evident, and adoption for this response is extremely limited.

3. Graduate Research

Several master's theses have been written by experts within the first responder community addressing the role of firefighters during tactical police operations. In his 2011 Naval Postgraduate School Master's thesis, firefighter Sean Newman proposes the use of a small elite inter-agency unit of pre-first responders—composed of firefighters and police officers—to enter hostile zones to engage terrorists, suppress the fire, and rescue hostages.⁴⁰ He recognizes the predicament facing firefighters and police officers when confronted with a dynamic attack, “Currently, compartmented standard operating procedures for first responders do not adequately address active shooter terrorist attacks when fire and explosives are combined with conventional firearms.”⁴¹ Known as a syndicated, water-enabled, anti-siege response matrix (SWARM), this elite response group would enter as a pre-strike team to stabilize the threat environment sufficiently to allow other officers to enter the structure and continue clearing the building.⁴² In another 2011 Naval Postgraduate School Master's thesis, Battalion Chief Paul Atwater, a veteran firefighter, advocates the use of “a force protection model in which law enforcement officers accompany and protect fire fighters in the warm zone.”⁴³ Atwater's proposal focuses on the use of first responder task forces specifically for the extrication of victims found in the warm zone. His proposal shares several operational similarities with the subsequent recommendations made by the Department of Homeland Security, the Federal

⁴⁰ Sean Newman, “Braving the Swarm: Lowering Anticipated Group Bias in Integrated Fire/Police Units Facing Paramilitary Terrorism” (master's thesis, Naval Postgraduate School, 2011), 43.

⁴¹ Ibid.

⁴² Ibid.

⁴³ Paul A. Atwater, “Force Protection for Fire Fighters: Warm Zone Operations at Paramilitary Style Active Shooter Incidents in a Multi-Hazard Environment as a Fire Service Core Competency” (master's thesis, Naval Postgraduate School, 2012), 9.

Emergency Management Agency, the IAFC, and the IAFF to increase the survivability of the victims.⁴⁴

Theodore Moody's research supports not cross-training across disciplines, but rather, a task force with specialists from different first responder disciplines to complement one another. Moody cautions against the reliance on SWAT units in active shooter and paramilitary assault incidents, asserting their historic extended response times would further risk the hostages' safety.⁴⁵ Instead, he recommends integrated teams consisting of "*first* first responders," on-duty patrol officers and firefighters, with the tactical objective of quickly neutralizing the terrorists to stop the killing of hostages and to suppress the fire as necessary.⁴⁶ To date, no fire department has implemented Moody's integrated team recommendation.

Deputy Fire Chief Keith Johnson's thesis examines the need for public agencies to implement integrated plans across multiple disciplines and justifies the need for cross-disciplined teams to coordinate at the response level, "To safely and efficiently mitigate emergent complex, paramilitary events, and encourage the collaboration of police, fire and EMS agencies, first responders should incorporate response frameworks to include strategic and operational policies that are compatible with each other, and align with their respective cultures."⁴⁷ Johnson argues that the mere creation of departmental policies supporting fire and law enforcement integration will not be sufficient; coordinated incident action plans deployed at the line level by the end-users—the first arriving patrol

⁴⁴ International Association of Firefighters, *IAFF Position Statement: Active Shooter Events*; International Association of Fire Chiefs, *Active Shooter and Mass Casualty Terrorist Events* (Fairfax, VA: International Association of Firefighters, 2013), http://www.iafc.org/files/1ASSOC/IAFCPosition_ActiveShooterEvents.pdf, and Office of Health Affairs; Department of Homeland Security, *First Responder Guide to Improving Survivability in Improvised Explosive Device and/or Active Shooter Incidents*, 9.

⁴⁵ Theodore Moody, "Filling the Gap between NIMS/ICS and the Law Enforcement Initial Response in the Age of the Urban Jihad" (master's thesis, Naval Postgraduate School, 2010), 44.

⁴⁶ *Ibid.*, 48.

⁴⁷ Keith Johnson, "Changing the Paradigm: Implementation of Combined, Law Enforcement, Fire, and Emergency Medical Service (EMS) Cross-Disciplinary Response to Hostile Events" (master's thesis, Naval Postgraduate School, 2014), 1.

officers and firefighters—are key components to successful integrated public safety responses during complex hostile events.⁴⁸

4. Future Role as Tactical Firefighters

Theodore Moody presents the only counter-argument cautioning against the over-reliance on SWAT teams for incidents in which multidisciplinary first responder integration is needed to protect the public.⁴⁹ The literature demonstrates a need for ongoing dialogue to seek solutions related to interior fire suppression during active shooting and terrorist events so that hostages can be rescued. What seems to be missing from the majority of the literature is the recognition that internationally, armed terrorist attacks are more dynamic and more unpredictable than typical American active shooter incidents; hot zones and warm zones will not remain static during an incident. Incidents can be dynamic particularly when multiple assailants conduct simultaneous attacks and employ additional weapons, such as IEDs and fire.

C. HISTORY

Several historical events illustrate the need to reevaluate alternative first responder strategies for response to asymmetric attacks and demonstrate the necessity of placing firefighters within a combined law enforcement and firefighter hot zone. In addition, a review of American news reveals that not all asymmetric attacks involve mass casualties and therefore do not attract nationwide news coverage. While it is not yet common for fire to be effectively deployed by assailants to confuse and delay access to hostages and victims, public safety personnel need to be prepared to respond when fire is used as a weapon during a hostile event.

1. Columbine

Although not considered a terrorist attack, the April 20, 1999 assault at Columbine High School in Colorado was a watershed moment in public safety. On that

⁴⁸ Johnson, “Changing the Paradigm: Implementation of Combined, Law Enforcement, Fire, and Emergency Medical Service (EMS) Cross-Disciplinary Response to Hostile Events,” 69.

⁴⁹ Moody, “Filling the Gap between NIMS/ICS and the Law Enforcement Initial Response in the Age of the Urban Jihad,” 47.

day, two teenagers mounted a multi-hazard attack at a high school using small arms and 76 homemade IEDs.⁵⁰ Their initial plan was to cause an explosion and fire in the cafeteria by detonating two 20-pound propane bombs and to shoot the fleeing survivors.⁵¹ The plan failed, but by later shooting at the propane bombs, the teens managed to start a small fire in the cafeteria that caused the sprinkler system to activate.⁵² Computer modeling suggests that had the propane bombs detonated, the resulting fireball and explosion would have killed and severely injured the students in the cafeteria that day.⁵³ During the assault, the perpetrators successfully detonated 30 of their incendiary and explosive devices before committing suicide.⁵⁴ Approximately 1.5 hours after the first shots were fired, SWAT requested firefighting assets to extinguish the fire in the cafeteria. An ad hoc firefighting task force composed of firefighters willing to volunteer for the hazardous duty assignment was formed to develop an action plan to address the possibility of additional fire spread.⁵⁵ In total, 13 people were killed and 24 were wounded through the assailants' combined use of fire, IEDs, handguns, and long guns.

Among the after action reports generated following the attack at Columbine High School, the United States Fire Administration published "Wanton Violence at Columbine High School."⁵⁶ The report made several recommendations for strategic changes within the fire service. The findings cited the failure of using "stage and wait" protocols for

⁵⁰ United States Fire Administration, *Wanton Violence at Columbine High School*, Technical Report Series (Washington, DC: United States Fire Administration, 1999), 25–26.

⁵¹ *Ibid.*, 10.

⁵² *Ibid.*, 11–12; State of Colorado, *The Report of Governor Bill Owens' Columbine Review Commission*, 23; The report documented a total of 99 incendiary explosive device: 13 additional IEDs were found in or around the assailants' cars, eight unexploded bombs were discovered in their homes, and two diversionary backpack bombs had been deployed about three miles from the school earlier that day.

⁵³ Jefferson County Sheriff's Office, *Report on the Columbine High School Shootings: Law Enforcement, Fire/EMS Agencies Responding to Columbine High School Shootings* (Evergreen, CO: Jefferson County Sheriff's Office, 1999); "Cover Letter from Sheriff John P. Stone," May 15, 2000, http://www.cnn.com/SPECIALS/2000/columbine.cd/Pages/INTRO_TEXT.htm; United States Fire Administration, *Wanton Violence at Columbine High School*, 35.

⁵⁴ United States Fire Administration, *Wanton Violence at Columbine High School*, 1.

⁵⁵ *Ibid.*, 18–21.

⁵⁶ United States Fire Administration, *Wanton Violence at Columbine High School*.

SWAT and waiting for complete “all-clears” from law enforcement. The report suggested the formation of police officer, and firefighter, and EMT teams to rescue the injured for more rapid medical intervention.⁵⁷

As a result, law enforcement agencies across the country adapted their tactics from waiting for SWAT to confront the assailant, to deploying the first arriving police officers rapidly to engage the shooter and stop the victims from dying.⁵⁸ Fire and EMS agencies, however, continued with their stage and wait protocols.⁵⁹ It would take years for fire departments to begin changing their response models to the increasingly lethal active shooter and mass casualty incidents that have become a regular occurrence across America. Following a 2009 full-scale exercise that resulted in an unacceptably delayed EMS response during a mass casualty, the nationwide efforts to develop integrated protocols for coordinated EMS and law enforcement teams were led by Arlington County, Virginia.⁶⁰

2. Rescue Task Forces

Arlington’s development and implementation of the Rescue Task Force model resulted after a 2009 full-scale exercise that revealed response gaps in Arlington’s mass casualty response model.⁶¹ The after action report uncovered several limitations exacerbated by the exclusive reliance on SWAT teams and SWAT medics to mitigate active shooter events and treat the wounded. What resulted was the rescue task force (RTF) concept in which law enforcement provides armed protection to firefighters and emergency medical personnel while they rescue the injured. RTFs differ from tactical medics in that line firefighters and patrol officers form combined teams at the incident

⁵⁷ United States Fire Administration, *Wanton Violence at Columbine High School*, 18–21.

⁵⁸ Katherine W. Schweit, “Addressing the Problem of the Active Shooter,” FBI Law Enforcement Bulletin, May 2013, <https://leb.fbi.gov/2013/may/addressing-the-problem-of-the-active-shooter>; Illinois State Police Academy, *Rapid Deployment as a Response to an Active Shooter Incident* (Springfield, IL: Illinois State Police Academy, 2003), 4.

⁵⁹ J. Pete Blair and M. Hunter Martaindale, *United States Active Shooter Events from 2000 to 2010: Training and Equipment Implications* (San Marcos, TX: Texas State University, 2013).

⁶⁰ Smith, Iselin, and McKay, “Toward the Sound of Shooting: Arlington, VA, Rescue Task Force Represents a New Medical Response Model to Active Shooter Incidents,” 49–55.

⁶¹ Ibid.

and do not wait for SWAT to arrive. The police provide force protection in the warm zone while firefighters and EMS personnel extricate victims out of the hazard zone. This concept was initially slow to be accepted and implemented around the country but has gained momentum after support from the IAFF, the IAFC, and the International Association of Police Chiefs. It has gained national support from the Federal Emergency Management Association (FEMA), and while it is not mandatory, it has developed into an industry standard.⁶² The public has come to expect this level of intervention, yet despite the support for the model, some fire departments have been slow to implement the RTF concept within their jurisdictions.⁶³

Key takeaways from Arlington's RTF protocols involve creating teams of two to three police officers—front and rear guards—paired with several firefighters and EMTs to assist the victims. Arlington's protocols also recommend providing firefighter RTF members with ballistic protection (rifle plates) and Kevlar helmets. The police officers escort the firefighters or EMTs into the warm zones where no direct threat is present, although the area has not been searched to the extent that police have declared it completely clear of all potential hazards. While this model has demonstrated success in active shooter environments, it does not consider the introduction of fire into the threat mix, and therefore, has limitations in its application.

3. The 2008 Mumbai Attacks

The quintessential paramilitary attack involving the inclusion of fire into the threat environment occurred in 2008, when 10 heavily armed members of Lashkar-e-Taiba (LeT) conducted multiple coordinated assaults of soft targets in Mumbai, India, including a restaurant, a hotel, and the train station. The attackers combined the use of assault rifles, hand grenades, IEDs, and fire while holding dozens of hostages.

⁶² Department of Homeland Security, *First Responder Guide for Improving Survivability in Improvised Explosive Device and/or Active Shooter*, 19–20.

⁶³ Marino et al., "To Save Lives and Property: High Threat Response."

Ultimately, the three-day assault resulted in the deaths of 166 people and the wounding of over 300 victims.⁶⁴

Using conventional low-tech attack methods, the attackers were able to effectively delay the first responders because of the latter's failure to prepare for a multiple modality attack. Intercepted conversations between the attackers and their handlers indicated that within four hours of taking the Taj Mahal Hotel, the attackers set several fires to create chaos inside and attract media attention.⁶⁵ Due to the hostage component and the number of heavily armed, trained terrorists, the Mumbai attack was more reminiscent of an urban warfare scenario than the active shooter event typically seen in the United States.⁶⁶ The assault involved taking numerous hostages with no intent of releasing them, leading to large numbers of casualties.

Iconic news footage captured the efforts of fire personnel raising ladders to rescue hostages from balconies who were hanging from windows of the Taj Mahal hotel during the siege.⁶⁷ Despite the absence of strategies, equipment, and tactics, the responding police officers and firefighters repeatedly risked their lives and did the best they could with what their departments had provided them. Similarly, firefighters and EMTs improvised while exposed to gunfire and grenades, borrowing ballistic vests, and evacuating injured police officers from the multiple attack locations.⁶⁸

Catastrophic incidents, such as Mumbai, demonstrate the unforeseen complexity facing first responders, far transcending the hazards and injuries typically encountered by the emergency response community in the United States. This seminal event

⁶⁴ Shahrzad Rizvi and Joshua Kelly, "The Continued Relevance of the November 2008 Mumbai Terrorist Attack: Countering New Attacks with Old Lessons," *Homeland Security Affairs* 11, art. 6, June 2015, 2.

⁶⁵ "Mumbai Terrorist Attacks Report: November 26–29, 2008," July 6, 2009, 52–53, <http://www.investigativeproject.org/documents/277-mumbai-terror-attacks-dossier-of-evidence.pdf>.

⁶⁶ Simon O'Rourke, "The Emergency Challenges for Policing Terrorism: Lessons from Mumbai," in *Proceedings of the 1st Australian Counter Terrorism Conference* (Edith Cowan University, Perth Western Australia, 2010), 46.

⁶⁷ "Unnoticed Heroes on Mumbai Attacks: Fire Fighters," November 29, 2008, <http://www.indianexpress.com/story-print/392212/>; *Subcommittee Hearing: Protecting the Homeland against Mumbai-Style Attacks and the Threat from Lashkar-E-Taiba* (2013) (Assistant Fire Chief Joseph W. Pfeifer).

⁶⁸ "Unnoticed Heroes on Mumbai Attacks: Fire Fighters."

demonstrated the need for police and firefighters to coordinate their tactics, strategies, and equipment for incidents involving shooting and fires simultaneously taking place to rescue hostages and victims.

Terrorism scholar Brian Jenkins states that a successfully executed “Mumbai-style attack is conceivable in the United States,” despite the fact that several plots have been foiled since 9/11.⁶⁹ In addition to international terrorists, homegrown violent extremists have engendered a sustained level of right-wing inspired domestic terrorism.⁷⁰ To date, lone attackers have overwhelmingly executed most of these assaults; however, “leaderless resistance” doctrine that inspires right-wing and left-wing extremists also advocates for attacks by small cells of no more than six attackers, more than enough individuals to carry out a Mumbai-style assault.⁷¹ Although responders have consistently neglected to develop the strategies necessary to respond to this attack method, the use of fire as a weapon is actually an ancient technique.

4. Fire as a Weapon

Humans have a long history of using fire in warfare. In the fifth century B.C., Sun Tzu devoted an entire chapter in his military treatise, *The Art of War*, to the strategy of attacking the enemy with incendiary weapons.⁷² He described the tactical advantage gained by attacking once the flames reached their height and the confusion faced by the unprepared enemy. The tactic of using fire as a weapon was effectively demonstrated by the United States armed forces during WWII, which resulted in the deadliest air raid of the war. On March 9, 1945, 339 B-29 bombers rained over 1,500 tons of firebombs on Tokyo using white phosphorous and napalm. About 15 square miles were destroyed, an

⁶⁹ *The Threat of a Mumbai-Style Terrorist Attack in the United States*, “Testimony submitted before the House Homeland Security Committee, Subcommittee on Counterterrorism and Intelligence (2013) (Brian Michael Jenkins).

⁷⁰ Ryan Lenz and Mark Potok, *Age of the Wolf: A Study of the Rise of Lone Wolf and Leaderless Resistance Terrorism* (Montgomery, AL: Southern Poverty Law Center, 2015), 40, http://www.splcenter.org/sites/default/files/downloads/publication/lone_wolf_special_report.pdf.

⁷¹ Louis Beam, “Leaderless Resistance,” *The Seditonist* #12, 1992, <http://www-personal.umich.edu/~satran/Polisci%2006/Wk%2011-1%20Terrorism%20Networks%20leaderless-resistance.pdf>.

⁷² Sun Tzu, *The Art of War* (Sweden: Chiron, 2015), Kindle edition, location 2681, <https://read.amazon.com/?asin=B0199LTIKI>.

area half the size of Manhattan. Civilian fatalities were estimated at 130,000 and over one million inhabitants were injured. In addition, 63% of Tokyo's commercial area and 18% of its industrial base was destroyed.⁷³ While the attacks of Hiroshima and Nagasaki have dominated history, the firebombing of Tokyo accounted for more civilian deaths in Japan than the atomic bombs used a few months later.⁷⁴

The Columbine and Mumbai attacks are not the only recent instances in which fire has effectively been used as a weapon against civilian targets. In the 2012 Benghazi attack, U.S. Ambassador Christopher Stevens and Information Officer Sean Smith died not from traumatic injuries, but from smoke inhalation as the compound burned.⁷⁵ The use of fire and firearms is not limited to large-scale events; occurrences of arson combined with shooting often fail to make national news, yet may be happening more frequently than might be assumed. News outlets in Philadelphia reported that on May 18, 2016, a teenager was lured outside when a Molotov cocktail was thrown on his front porch, starting a fire. When he went outside to investigate, he was shot multiple times.⁷⁶ Several people were inside the home at the time of the assault. On September 24, 2015, in Arkansas, two assailants firebombed a home and shot the 12 occupants as they fled the fire.⁷⁷ On April 11, 2016, a SWAT standoff in Clintonville, Ohio resulted in a gunfight with police, the shooting death of a police officer, and an apartment fire when the barricaded suspect refused to surrender.⁷⁸

In a guide published by the nation's leading homeland security practitioners, fire was identified as an effective means of attacking responders and citizens during hostile

⁷³ Edwin P. Hoyt, *Inferno: The Fire Bombing of Japan, March 9–August 15, 1945* (Lanham, MD: Madison Books, 2000), 40–48.

⁷⁴ Ibid.

⁷⁵ Lateef Mungin, "Benghazi Siege: The Ambassador's Last Minutes," December 19, 2012, *CNN*, <http://www.cnn.com/2012/12/19/us/benghazi-what-happened/>.

⁷⁶ Dan Stamm, "Porch Arson Leads to Shooting of Teenager," *NBC Philadelphia*, May 19, 2016, <http://www.nbcphiladelphia.com/news/local/Lebanon-Avenue-Arson-Shooting-379919241.html>.

⁷⁷ Curt Lanning, "Update: Arrest in Helena Arson-Shooting," *fox16*, September 24, 2015, <http://www.fox16.com/news/local-news/update-arrest-in-helena-arson-shooting>.

⁷⁸ John Futtly, "Shooting Suspect in Clintonville Standoff Was Wanted on Felony Warrant," *The Columbus Dispatch*, April 11, 2016, <http://www.dispatch.com/content/stories/local/2016/04/10/0410-officer-shot-in-clintonville.html>.

events to delay the emergency response or to create confusion.⁷⁹ As this nation's threat environment evolves, public safety organizations must recognize the needs of the communities they are sworn to protect and change as well. The literature confirms that new strategies, techniques, and service models should be adopted. Although the fire service as a whole has been slow to embrace its mission within traditional law enforcement incidents, some fire service organizations are leading the industry and have implemented new response models.

⁷⁹ "Active Shooter/Hostile Event (ASHE) Guide," July 2016, 31, <http://www.interagencyboard.org/sites/default/files/publications/IAB%20Active%20Shooter%20%26%20Hostile%20Event%20Guide.pdf>.

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III. TACTICAL FIREFIGHTER TEAMS: VISION AND CONCEPT

During its research of tactical firefighter teams, the HFD found a few examples of active teams throughout the country. This chapter describes the vision and concept for three of the industry's tactical fire team pioneers: Loveland Fire Rescue Authority, the CFD, and the FDNY. In light of the emerging complexity of the threat environment, and the need for coordinated public safety strategies, these fire service organizations have implemented variations of tactical firefighter ("Tac Fire") teams to assist law enforcement personnel during hostile events. In establishing the Tac Fire program, the Loveland Fire Rescue Authority has provided a possible mitigation strategy for hostile incidents requiring firefighting services in the midst of a law enforcement incident. Firefighters who are members of the Tac Fire Team provide suppression expertise and support for the SWAT team. Meanwhile, law enforcement members of the SWAT team provide armed protection to the firefighters while in warm zones. The CFD has implemented its own variation; known as police assist companies (PACs), designated ladder trucks and personnel respond at the request of the SWAT commander to provide firefighting and subject matter expertise. Another rare example of tactical firefighter teams comes from the FDNY where arriving firefighters can be escorted by law enforcement into police warm zones to suppress structure fires during assaults.

A. THE HOUSTON FIRE DEPARTMENT: HOUSTON, TEXAS

In the fall of 2010, the Mayor of Houston conducted a nationwide search for a fire chief and hired a 30-year veteran from the West Coast. The fire chief conducted several informal, internal evaluations to identify response gaps within its service delivery model.⁸⁰ It became apparent that strengths of the HFD revolved around what are considered traditional fire department core services: extinguishment of fires, hazardous material response, and pre-hospital emergency care.⁸¹ Opportunities for improvement involved strengthening the working relationship with the local police department since

⁸⁰ Houston Fire Department, "A Message from the Chief," July 11, 2011; Houston Fire Department, "A Message from the Chief," August 31, 2011.

⁸¹ Houston Fire Department, "A Message from the Chief," September 18, 2012.

departmental policies related to tactical, operational, and strategic support of law enforcement were outdated or non-existent.⁸² Although the HFD had instituted a homeland security office in the years following the 9/11 attacks, policy changes and new program implementation had stagnated since 2008.⁸³

While researching for more progressive policies involving joint police and fire task forces, the HFD identified three fire departments using variations of tactical firefighter teams able to support law enforcement during hostile events: the Loveland Fire Rescue Authority, the Charlotte Fire Department, and the FDNY. However, evaluations regarding the effectiveness of the tactical firefighter units did not appear to have been conducted. Furthermore, the three models did not enter into the hot zone nor offered equipment modifications to protect the teams from the range of hazards they could encounter. As a result, the HFD conducted a series of three field tests to evaluate equipment needs for a tactical fire team to make hot zone entry.

B. LOVELAND FIRE RESCUE AUTHORITY: LOVELAND, COLORADO

Loveland, Colorado, is located about 46 miles north of Denver. The City of Loveland and the surrounding rural community encompass 190 square miles; the City of Loveland itself measures 25 square miles. The region is protected by the Loveland Fire Rescue Authority (LFRA), which provides rescue, firefighting, and first responder EMS services (no hospital transport). Thompson Valley EMS is a separate agency that provides the region with paramedic and emergency transport services. Thompson Valley EMS also provides the SWAT team with tactical emergency medical support (TEMS) through tactical paramedics. The Loveland SWAT team is a level 3 team consisting of 28 police officers who have SWAT capabilities in addition to their regular patrol duties.⁸⁴

⁸² HFD lacked written standard operating procedures for a tactical medical program it had implemented. Houston Fire Department, *Strategic Plan Fiscal Years 2009–2013* (Houston, TX: Houston Fire Department, n.d.).

⁸³ Houston Fire Department, *Strategic Plan Fiscal Years 2009–2013*; Houston Fire Department, *Strategic Plan Fiscal Years 2011–2015* (Houston, TX: Houston Fire Department, n.d.).

⁸⁴ Email correspondence between Loveland Fire Rescue and Houston Fire Department, August 12, 2015.

In 2007, following a series of tactically complex emergencies involving clandestine drug labs, the LFRA created a special operations team composed of tactically trained, on-duty firefighters to assist the local SWAT team.⁸⁵ Known as Tac Fire, the team consists of seven team members and a battalion chief.⁸⁶ The Tac Fire program is modeled after nationally recognized tactical medical programs that have been in use around the country for over a decade. However, instead of providing medical support, Tac Fire provides fire suppression, forcible entry, technical rope applications, hazardous material operations, and first responders during warrant service and no-notice call-outs.⁸⁷ Rather than train SWAT officers to perform duties traditionally reserved for firefighters (breaching, fire suppression), Loveland has trained firefighters to work within the law enforcement environment at the direction of SWAT commanders.⁸⁸ Although Tac Fire members are trained to render weapons safe, they are not certified law enforcement officers and are not armed; SWAT members provide force protection to these firefighters while in the warm zone.

In 2015, Tac Fire responded to 21 call-outs with the SWAT team; however, after action reports to assess the effectiveness of the team have not been published.⁸⁹ Like the SWAT team, Tac Fire is not a freestanding unit in Loveland; members respond to routine calls throughout their shift. Tac Fire members undergo additional training to qualify them for a position on the SWAT team. Members are required to complete basic SWAT school successfully and to maintain competence in LFRA rope and technical rescue operations. Tac Fire members must also complete Loveland SWAT's bi-annual physical agility requirements to maintain their position on the team. In addition, Tac Fire members attend 10 hours of monthly scenario-based training with the SWAT team.

⁸⁵ Loveland Fire Rescue Authority, *General Operations Policy: Tactical Fire Team Operational Policy*, 1.

⁸⁶ Loveland Fire Rescue Authority, *Proposal for Tactical Fire Team* (Loveland, CO: Loveland Fire Rescue Authority, 2015), unpublished.

⁸⁷ Ibid.

⁸⁸ Loveland Fire Rescue Authority, *General Operations Policy: Tactical Fire Team Operational Policy*.

⁸⁹ "2015 Annual Report," 24, accessed July 17, 2016, <http://www.cityofloveland.org/modules/showdocument.aspx?documentid=29594>.

The goal of Tac Fire was to serve as a force multiplier for the SWAT team by serving the tactical support functions of carrying equipment, conducting air monitoring, dragging victims, forcing entry and breaching, and communicating with the incident commander.⁹⁰ Cost savings were also desired by avoiding redundant purchases for equipment. Tac Fire maintains and supplies the self-contained breathing apparatus (SCBAs) used by the SWAT team. In addition to subject matter expertise, Tac Fire provides the mechanical tools needed to force entry into structures (bolt cutters, saws, hydraulic tools, prying tools, etc.)—equipment that LFRA already had—while SWAT members stay on their weapons.⁹¹ Tac Fire members wear the same level of ballistic protection as SWAT; however, they do not combine the donning of ballistic equipment and firefighting protective equipment.

C. CHARLOTTE FIRE DEPARTMENT: CHARLOTTE, NORTH CAROLINA

With over 800,000 residents, and encompassing an area of almost 300 square miles, Charlotte is the largest and most populous city in North Carolina.⁹² Charlotte has a large risk profile. It is the second largest financial center in the United States and the only city in the world with two nuclear power stations and four reactors in close proximity to the downtown core.⁹³

Emergency response services are provided by several government agencies. Emergency medical services are provided by Mecklenburg County through an agency called MEDIC, which provides emergency medical transport to area hospitals and employs approximately 350 paramedics, EMTs, and emergency physicians.⁹⁴ The CFD employs about 1,100 firefighters and EMTs. In addition to providing the city's fire and rescue services, it also provides first responder medical care in the pre-hospital setting;

⁹⁰ Loveland Fire Rescue Authority, *Proposal for Tactical Fire Team*.

⁹¹ *Ibid*.

⁹² "United States Census Bureau," accessed July 13, 2016, <http://www.census.gov/>.

⁹³ "Advanced Local Response Team," accessed July 17, 2016, <https://www.medic911.com/operations/special-operations/advanced-local-response-team-alert>.

⁹⁴ "FY15 Financial Report," accessed July 14, 2016, [https://www.medic911.com/assets/user/upload/files/2015%20Annual%20Report%20sm\(5\).pdf](https://www.medic911.com/assets/user/upload/files/2015%20Annual%20Report%20sm(5).pdf).

however, the CFD does not provide medical transport to the hospital. The Charlotte-Mecklenburg Police Department (CMPD) is a combined city and county police force with 1,850 officers protecting an area of 438 square miles. In addition to responding to planned and no-notice SWAT callouts, the CMPD SWAT team has patrol and investigative duties.

The CMPD and MEDIC have developed a strong partnership over the years and have implemented two inter-agency teams. MEDIC has a special operations division specifically trained to assist the police when responding to hostile events, special events, and major disasters. This civil emergency unit (CEU) consists of 11 paramedics trained to mitigate civil disturbances and assigned to deploy with the CMPD CEU team during times of unrest.⁹⁵ Eight paramedics support the CMPD SWAT team and deploy to SWAT responses.⁹⁶ SWAT medics are required to complete basic SWAT school successfully and to attend the Counter Narcotics Tactical Operations Medical Support (CONTOMS) program provided by the U.S. Department of Defense. In addition, SWAT medics must complete 24 hours of monthly training with the SWAT team.

Following the 2012 Democratic National Convention, the CFD and the Charlotte-Mecklenburg Police Department recognized the necessity of developing joint strategies to address emergencies in which fire is used as a weapon.⁹⁷ Consequently, they have partnered and have designated two ladder companies as PACs. PAC members receive additional training related to tactical police operations and respond to most emergency SWAT deployments (barricaded subjects, hostage events, high-risk warrant service) on a standby basis.⁹⁸ Among the PAC's primary duties are suppressing fires during hostile events, rescuing injured officers, providing decontamination and supplementing tactical medic personnel during civil unrest, and assisting SWAT with forcible entry and with the

⁹⁵ "Civil Emergency Unit," accessed July 17, 2016, <https://www.medic911.com/operations/special-operations/civil-emergency-unit-ceu>.

⁹⁶ "Special Weapons and Tactics," accessed July 17, 2016, <https://www.medic911.com/operations/special-operations/special-weapons-tactics-swat>.

⁹⁷ Charlotte Fire Department, *Police Assist Company (PAC) Program Proposal* (Charlotte, NC: Charlotte Fire Department, 2012), unpublished.

⁹⁸ Ibid.

management of building HVAC systems. PAC personnel also assist SWAT by functioning as subject matter experts and providing information related to the construction and layout of buildings, inspection records, and building schematics. In addition, PAC firefighters and EMTs are specifically trained in tactical emergency casualty care (TECC) and function as a force multiplier for the tactical medics. By providing a cadre of trained and regular personnel to assist and support police operations, PAC members become familiar with specific police tactics and needs during complicated hostile incidents.⁹⁹

D. FIRE DEPARTMENT OF THE CITY OF NEW YORK

With a population of more than 8.5 million residents, New York is the largest city in the United States. It encompasses an area of 469 square miles of which 305 square miles are land and the rest is water area. The New York Police Department (NYPD) employs over 35,000 officers, making it the largest U.S. civilian police force.¹⁰⁰ In addition to being the site of the deadliest terrorist attack on American soil (September 11, 2001), New York City is also the American city most often targeted by terrorists; it has had numerous foiled plots, giving it one of the highest threat profiles in the country.¹⁰¹

The City of New York has developed the most robust counter-terrorism response capability in the country and is able to respond to active assaults within minutes.¹⁰² In 2015, the NYPD created a full-time counterterrorism unit known as the Critical Response Command (CRC).¹⁰³ The unit has 525 elite officers trained and armed to respond to the

⁹⁹ Charlotte Fire Department, *Police Assist Company (PAC) Program Proposal*.

¹⁰⁰ “Frequently Asked Questions|Police Administration,” accessed August 10, 2016, http://www.nyc.gov/html/nypd/html/faq/faq_police.shtml#1.

¹⁰¹ *House Committee on Homeland Security, “Beyond Bin Laden’s Caves and Couriers to a New Generation of Terrorists: Confronting the Challenges in a Post 9/11 World, Hearing before the U.S. House of Representatives, Committee on Homeland Security, 114th Cong., 1 (2015),* <https://www.hsdl.org/?view&did=791553>.

¹⁰² *Ibid.*

¹⁰³ Michael Wilson, “How an Elite New York Police Unit Rehearses for a Terrorist Attack,” *New York Times*, July 31, 2016, http://www.nytimes.com/2016/08/01/nyregion/new-york-police-prepare-terrorist-attack.html?_r=0.

most violent terrorist attacks.¹⁰⁴ When they are not training, the unit patrols the city and is further augmented by the Strategic Response Group (SRG); another newly created team of 700 patrol officers armed with high-powered rifles and trained to respond to active shooter events.¹⁰⁵ In addition to these two counter terrorism units, the NYPD also has the emergency service unit (ESU). ESU members have the combined skills sets traditionally seen in SWAT, hazardous materials (HazMat), and search and rescue teams.¹⁰⁶

The NYPD ESU has over 500 full-time police officers assigned to its various teams and responds 24/7/365 to the most complicated incidents within the city.¹⁰⁷ Personnel are trained in 22 different disciplines to include urban search and rescue (USAR), use of heavy firearms and weapons, HazMat response, high angle and water rescue, and hostage negotiation.¹⁰⁸ All ESU officers are certified emergency medical technicians (EMTs). In addition, the NYPD Tactical Medic Program is staffed with law enforcement ESU personnel who are certified paramedics, but are only allowed to administer advanced life support within the tactical environment. Annually, the ESU responds to over 150,000 callouts ranging from warrant service to rescues at train derailments.¹⁰⁹

The FDNY provides firefighting, rescue, and EMS services to the city. In addition, the FDNY has created several special operations units that assist during terrorist attacks and mass casualty events. As the largest American fire department, the FDNY employs over 11,000 firefighters and over 2,800 EMTs and paramedics. The FDNY

¹⁰⁴ Wilson, "How an Elite New York Police Unit Rehearses for a Terrorist Attack,"

¹⁰⁵ J. David Goodman, "With Permanent Squad, New York Police Step Up Fight on Terrorism," *New York Times*, November 20, 2015, <http://www.nytimes.com/2015/11/21/nyregion/new-york-police-form-counterterrorism-force-with-more-firepower-and-training.html?action=click&contentCollection=N.Y.%20%2F%20Region&module=RelatedCoverage®ion=EndOfArticle&pgtype=article>.

¹⁰⁶ "Press Release|50 New Members in NYPD Emergency Service Unit," December 14, 2012, http://www.nyc.gov/html/nypd/html/pr/pr_2012_12_04_esu_graduation_2012_12_04.shtml.

¹⁰⁷ "The Five T's: Taking Effect," accessed August 11, 2016, http://www.nyc.gov/html/nypd/downloads/pdf/home_features/2016-05-23_nypd-five-t-s.pdf.

¹⁰⁸ Jennifer Hsu, "Inside the NYPD's Elite Emergency Service Unit," Police Department City of New York, January 9, 2012, <http://www.wnyc.org/story/178955-blog-nypds-emergency-service-unit/>.

¹⁰⁹ "The Five T's: Taking Effect."

Bureau of Emergency Medical Services (EMS) provides the city's prehospital emergency medical care, staffing basic ambulances with EMTs, and advanced life support ambulances with paramedics. The EMS Bureau also has a special operations hazardous materials tactical (Haz-Tac) battalion that provides Haz-Tac units (Haz-Tac ambulances) and rescue medics.¹¹⁰

Following the 2008 Mumbai attack, the NYPD and FDNY jointly studied the tactics and strategies of the terrorists and responders. Based on the lessons learned, the FDNY and NYPD created new interagency and interdisciplinary strategies toward their homeland security efforts.¹¹¹ They implemented a program similar to Arlington's rescue task force program. The FDNY's integrated tactical response teams (ITRTs) are composed of line police officers, firefighters, and EMS personnel.¹¹² Unlike Loveland, FDNY firefighters do not receive ballistic vests or specialized training related to police tactics or team movement. The ITRTs fall under the direction of the incident commander (law enforcement) and are escorted by the NYPD into the warm zone as needed. In addition to assisting with EMS functions and victim evacuation, the FDNY supports police tactical operations by serving as subject matter experts in building information, such as building layout, heating, ventilation, and air conditioning (HVAC) systems, standpipe and sprinklers, and the fire service recall of elevators.¹¹³

Firefighters also assist with the restoration of damaged fire protection systems and the creation of water supplies to control fire spread. The restoration of fire suppression and fire protection systems is vital to controlling fire spread in large high rises with numerous occupants, and can include the physical repair by firefighters of compromised systems.¹¹⁴ By using positive ventilation and their knowledge of HVAC systems,

¹¹⁰ Haz-Tac ambulances are staffed with personnel who can provide medical services within a HazMat environment. Rescue medics are ambulances staffed with paramedics who are also HazMat technicians and are trained in high angle rescue and trench rescue and other urban search and rescue techniques.

¹¹¹ Fire Department of the City of New York, *Interagency Tactical Response Model: Integrating Fire and EMS with Law Enforcement to Mitigate Mumbai-Style Terrorist Attacks*, 5.

¹¹² Ibid.

¹¹³ Fire Department of the City of New York, *Interagency Response Protocol to Active Shooter Incidents* (New York: Fire Department of the City of New York, 2014), 5.

¹¹⁴ Ibid.

firefighters, and available building and maintenance personnel can assist law enforcement by moving smoke away from areas of refuge for trapped victims and hostages. Fire suppression teams can also be integrated with SWAT members to extinguish fires, set up master streams, and force entry.¹¹⁵ The FDNY is also able to provide supplemental equipment, such as SCBAs or thermal imaging cameras.

Information regarding the number of annual callouts for ITRTs is not available; however, the FDNY periodically assesses its capability and capacity to respond to mass casualty incidents and terrorist attacks through workshops, tabletop exercises, and full-scale exercises, averaging between 35–40 preparedness exercises per year.¹¹⁶ Although New York has not faced a successful incendiary attack by terrorists since 9/11, the department continues actively to address the need to respond aggressively to such an event and has concluded that additional firefighting resources and training need to be devoted to mitigate the use of fire as a weapon. On September 8, 2015, Daniel Nigro, Commissioner of the New York City Fire Department, provided Congressional testimony before the House Committee on Homeland Security.¹¹⁷ During his statement, he briefly described the partnership between the FDNY, NYPD, the Federal Bureau of Investigation (FBI), and the Department of State’s Diplomatic Security Services, “to develop the procedures for joint tactical teams—teams comprised of fire personnel and security forces operating together—in an environment with armed terrorists, fire and smoke, and mass casualties.”¹¹⁸

E. LESSONS LEARNED FROM EARLY MODELS

Public safety practitioners are actively seeking to develop strategies to address hostile events incorporating the use of fire as an attack method.¹¹⁹ The tactical firefighter

¹¹⁵ Fire Department of the City of New York, *Interagency Tactical Response Model: Integrating Fire and EMS with Law Enforcement to Mitigate Mumbai-Style Terrorist Attacks*, 7.

¹¹⁶ House Committee on Homeland Security, “Beyond Bin Laden’s Caves and Couriers to a New Generation of Terrorists: Confronting the Challenges in a Post 9/11 World, Hearing before the U.S. House of Representatives, Committee on Homeland Security.

¹¹⁷ Ibid.

¹¹⁸ Ibid.

¹¹⁹ “Active Shooter/Hostile Event (ASHE) Guide,” 31–32.

teams discussed have attempted to fill operational gaps during complex hostile incidents when a multiple disciplinary approach is required to save lives. Each model was developed independently by the local departments and is tailored to the risk profile of each local jurisdiction. The Loveland Tac Fire team and the Charlotte PACs were specifically created to support law enforcement by embedding fire personnel within the SWAT teams. The members of those teams are vetted for specific skill sets and are required to maintain a pre-defined level of physical fitness to qualify. Successfully completing annual physical agility and SWAT scenario-based testing are requirements of staying on the team. In addition, the members of Loveland Tac Fire and Charlotte PAC are required to participate in monthly training with the SWAT team. Tactical movement and team integration are reinforced by having the same cadre of firefighters and police officers working and training together. Of the three teams, Loveland is the only one that provides firefighters with ballistic vests and headgear, although all three teams work within the warm zone when escorted by police.

The FDNY model uses responding line personnel to form firefighting and police rescue task forces during hostile events. Unlike the other two models in which a cadre of select firefighters train with specific law enforcement personnel, New York's model does not provide additional tactical police training or awareness to its firefighters. Furthermore, police officers and firefighters often do not know each other since they do not drill or exercise together on a regular basis. However, in creating the RTF firefighting model, the FDNY has ensured that any of New York City's 11,000 firefighters can respond with any of the 35,000 law enforcement officers within the city's 469 square miles, 24 hours a day, 365 days a year. New York's model provides for abundantly available public safety rescue task force teams who can arrive at an incident within minutes and can respond to multiple simultaneous attacks without depleting its workforce. The New York model does not prioritize the pre-establishment of relationships through integrated training and familiarization with the other's operating procedures, equipment, and tactics. In contrast, Loveland Tac Fire and Charlotte PAC have a limited number of available tactical firefighters to respond with SWAT team members. Loveland Tac Fire members are assigned to a single fire station within its 190

square mile area of response while the Charlotte PAC has team members assigned to two fire stations across 300 square miles. However, as indicated by Fire Commissioner Daniel Nigro, New York is in the process of creating additional procedures for joint tactical teams that would combine firefighters with local and federal law enforcement personnel to “enter an environment in which armed terrorists, fire, and mass casualties are present;” which appears similar to the model proposed by Theodore Moody.¹²⁰

The jurisdictions discussed developed their tactical firefighter teams to respond to high consequence, low frequency events. Although variations to the deployment of the different models exists, all three jurisdictions established strategies to assist law enforcement by enabling police officers to focus on their primary mission of neutralizing assailants and securing the perimeter without having to engage in support activities traditionally conducted by firefighters. In addition to maximizing personnel resources, the establishment of tactical firefighter teams appears to suggest cost savings to local jurisdictions by making firefighting tools, such as breaching equipment, thermal imaging cameras, and SCBAs readily available to law enforcement. However, a limitation shared by all three teams is the inability to progress beyond the warm zone into high hazard areas, particularly in situations in which fire and smoke are present.

F. REMAINING GAPS

Hostile environments increasingly require a cross-disciplinary incident response by first responders; however, numerous instances of dynamic threat environments happen in which first responders were unable to enter the hot zone because they lacked an appropriate protective gear ensemble. A recent example occurred in June 2016 in Fremont, California during a SWAT standoff in which a barricaded suspect held a hostage at a residential house fire. Although firefighters were on scene and attempted to extinguish the fire from the outside while SWAT provided force protection, the team was

¹²⁰ House Committee on Homeland Security, “Beyond Bin Laden’s Caves and Couriers to a New Generation of Terrorists: Confronting the Challenges in a Post 9/11 World, Hearing before the U.S. House of Representatives, Committee on Homeland Security.

unable to enter the structure because the barricaded suspect was still inside.¹²¹ The fire department could not risk entry for fear of being shot, and law enforcement personnel lacked turnout gear and the firefighting training/tactics to enter an incendiary environment.

Beginning in 2003, the Department of Homeland Security initiated a series of studies to evaluate the capability needs of first responders during catastrophic incidents.¹²² The studies identified “the stove piped approach to PPE development” that continues to limit protective equipment for use within specific disciplines despite the emergence of multiple hazards during catastrophic events.¹²³ Responders are increasingly deploying to events that pose a greater range of hazards not traditional to their discipline, and find themselves lacking the necessary protective equipment to enter the hot zone successfully.¹²⁴ The studies concluded that first responders of the future will require a modular protective gear ensemble that allows them to mix and match protective equipment commensurate with the hazards they face at an incident.¹²⁵ However, in the absence of a commercially available modular protective ensemble, first responders find it necessary to protect themselves through currently available resources.

In a white paper assessing the effectiveness of the public safety response to the November 2015 Paris attacks, the authors noted that the effective management of a terrorist incident will require “appropriate equipment and training to neutralize or at least contain the terrorists.”¹²⁶ National guidance from FEMA and the InterAgency Board (IAB), and jurisdiction-specific protocols recognize the need to create interagency

¹²¹ “Tear Gas Sparks Fire That Kills Suspect in Shooting of 2 Fremont Officers,” June 2, 2016, <http://abc7news.com/news/tear-gas-sparks-fire-that-kills-suspect-in-shooting-of-2-fremont-officers/1367974/>.

¹²² Department of Homeland Security, *Project Responder 4: 2014 National Technology Plan for Emergency Responders to Catastrophic Incidents* (Washington, DC: Department of Homeland Security Science and Technology Directorate, 2014), 1.

¹²³ *Ibid.*, 89.

¹²⁴ *Ibid.*, 92.

¹²⁵ *Ibid.*

¹²⁶ Homeland Security Advisory Council, *The Attacks on Paris: Lessons Learned* (Washington, DC: Homeland Security Advisory Council, 2016), 26, http://hsacouncil.org/Documents/20160607_Paris_WhitePaper_Master%20FINAL.pdf.

communication plans and tactically integrated response plans for multijurisdictional teams.¹²⁷ However, integration of policy and tactical action plans must be supported with the ability to integrate protective equipment ensembles for a mixed threat environment. What is missing from the literature is a systematic analysis of the specific equipment a cross-disciplined team needs and can realistically deploy in a dynamic threat environment. For example, the IAB recommends that police and fire train together before using specialized equipment, such as SCBAs during an emergency incident, and suggests the use of ballistic cylinder covers to protect SCBAs from projectiles; however, ballistic resistant cylinder covers are not a protective item currently readily available outside of the military environment.¹²⁸ In the absence of the appropriate specialized equipment to enter austere environments, responders will have limited entry to the hot zone, potentially posing tactical disadvantages.

¹²⁷ “Active Shooter/Hostile Event (ASHE) Guide,” 7; Department of Homeland Security, *First Responder Guide for Improving Survivability in Improvised Explosive Device and/or Active Shooter Incidents*, 15.

¹²⁸ “Active Shooter/Hostile Event (ASHE) Guide,” 31.

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IV. PROTECTIVE EQUIPMENT NEEDS FOR TACTICAL FIREFIGHTER ENTRY TEAMS

The previous chapter described the limitation of early tactical fire team models in their ability to progress into hot zones in which ballistic and incendiary weapons are simultaneously present. This chapter discusses the technology and equipment needs that a group of cross-trained *first* first responders needs to enter an austere multiple threat environment to extinguish the fire, free hostages, and neutralize assailants. During its research, the HFD identified equipment used across public safety disciplines that could be used in non-traditional combinations to provide protection to a tactical firefighter entry team.¹²⁹ It then designed various procedures to evaluate the feasibility of introducing the equipment to conditions that simulated a fire environment with the discharging of firearms. While extremely rugged, firefighting protective equipment was never designed to withstand the impact of gunfire and provides no protection against projectiles. In light of this, the HFD elected to specifically evaluate SCBAs, gloves, and ballistic vests in combination with firefighting personal protective equipment (PPE).¹³⁰

As was noted by the IAB, fire can also be used as a weapon during ambushes of first responders, barricaded suspect situations (with or without hostages), during civil unrest since arson and firebombing are common tactics, and through arson in forested areas either near urban communities or in rural locales.¹³¹ Therefore, an initial entry team needs to be equipped appropriately to navigate what could potentially be a hot, smoke-filled, low-visibility environment typically encountered during fires; in addition, threats could also include those traditionally mitigated by law enforcement personnel, such as gunfire and IEDs. During its research, the HFD concluded that using a combination of

¹²⁹ Houston Fire Department, internal memo, August 3, 2015.

¹³⁰ Ibid.

¹³¹ “Active Shooter/Hostile Event (ASHE) Guide”; Dan Friedman, “Baltimore Burns as Rioters Attack Firefighters, Leaving Residents Angry,” *New York Daily News*, April 28, 2015, <http://www.nydailynews.com/news/national/baltimore-burns-rioters-attack-responding-firefighters-article-1.2201560>; Tom Foreman Jr. and Amanda Lee Myers, “Baltimore Fire Trucks Pelted with Cinder Blocks During Baltimore Riots,” *Associated Press*, April 28, 2015, <http://www.firerescue1.com/firefighter-safety/articles/2163999-Baltimore-Fire-trucks-pelted-with-cinder-blocks-during-riots/>.

traditional firefighting gear and tools, ballistic protection worn by police officers, and gloves that provide thermal protection and dexterity for firearms manipulation, will allow first responders to enter the hot zone effectively during a multi-threat environment involving ballistic and incendiary threats.¹³² The HFD's analysis builds on the traditional firefighting PPE ensemble by suggesting modifications to the gloves and incorporating ballistic protection and helmet-mounted thermal imaging camera technologies in the context of a tactical firefighter entry team.

A. PROTECTIVE EQUIPMENT

Traditional structural firefighting PPE consists of an ensemble: turnout gear, helmet, boots, hood, SCBA, facepiece, and gloves.¹³³ This protective equipment is governed by the National Fire Protection Association (NFPA), which designates minimum protective requirements for PPE within incendiary environments.¹³⁴ One of the most important minimum protective requirements is addressed by NFPA 1971, which includes thermal protection standards. Turnout gear and gloves must have a minimum thermal protection performance (TPP) rating of 35.¹³⁵ The TPP test, developed by DuPont in the 1970s, "measures the amount of time before temperature and energy transferred to the fabric reach a level that would cause a second-degree burn to the wearer of the PPE."¹³⁶ A TPP of 35 means the garments must protect the wearer from sustaining second-degree burns for at least 17.5 seconds in flashover conditions.¹³⁷

¹³² Houston Fire Department, internal memo, January 4, 2016.

¹³³ David W. Dodson, *Firefighter's Handbook: Firefighting and Emergency Response*, 2nd ed. (Clifton Park, NY: Delmar Learning Executive Wood, 2004), 127.

¹³⁴ National Fire Protection Association, *NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*, 2013 ed. (Quincy, MA: National Fire Protections Association, 2013), <http://www.nfpa.org/codes-and-standards/free-access>.

¹³⁵ *Ibid.*

¹³⁶ "Thermal Protection Performance Test," accessed September 10, 2015, <http://www.dupont.co.uk/products-and-services/personal-protective-equipment/thermal-protective-apparel-accessories/articles/dupont-thermal-protection-performance-test.html>.

¹³⁷ National Fire Protection Association, *NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*.

1. Structural Firefighter Turnout Gear

Firefighter protective clothing is designed with the primary purpose of limiting heat transfer to the wearer to provide the interior structural firefighter with time to extinguish the fire.¹³⁸ Turnout or bunker gear consists of a coat and pants constructed with three layers.¹³⁹ The outer shell is typically constructed from Nomex or Kevlar, strong, lightweight fabrics that withstand punctures and abrasions in addition to being fire-resistive.¹⁴⁰ A vapor barrier follows and provides protection from chemicals and steam burns; the inner layer provides protection from thermal injury.¹⁴¹ While turnout gear protects the wearer from thermal injury and chemicals, it provides no protection against gunfire or IEDs. Therefore, in an environment in which gunfire and thermal hazards are present, ballistic protection will need to be incorporated into the protective ensemble. However, the additional weight of a ballistic vest and the added thermal burden could potentially render the combination unfeasible within a heated environment.

2. Helmets, Boots, and Hoods

Helmets, boots, and hoods are integral parts to the firefighting protective equipment ensemble but were not field tested by the HFD due to a belief that these articles would not need modification.¹⁴² Firefighting helmets provide protection against impact from falling, burning objects and against heat; however, they lack ballistic protection.¹⁴³ In high threat environments, law enforcement personnel may elect to wear ballistic helmets constructed of Kevlar capable of stopping rifle rounds, but ballistic helmets have not been tested and approved for a fire environment. Additional testing and research will be needed to determine whether the ballistic helmet is fire resistive or can

¹³⁸ Dodson, *Firefighter's Handbook: Firefighting and Emergency Response*, 127.

¹³⁹ National Fire Protection Association, *NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*.

¹⁴⁰ "Thermal Protection Performance Test."

¹⁴¹ *Ibid.*

¹⁴² Houston Fire Department, internal memo, August 3, 2015.

¹⁴³ National Fire Protection Association, *NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*.

be modified for a fire environment. Helmets were not tested by the HFD and should be an area of inquiry for future research.

Boots are typically constructed of leather or rubber and are designed to protect against chemicals, heat, and sharp objects.¹⁴⁴ Structural firefighting boots are notoriously heavy and could potentially contribute to fatigue during extended operations. The HFD did not field test nor offer recommendations for boots. Protective hoods protect the head and neck by encapsulating them with a flexible knit hoods or a more rigid Reed hood; both are designed to provide thermal protection.¹⁴⁵ The knit hood is constructed of a single layer of Nomex, while the Reed hood is a multi-layer garment with a Kevlar exterior that also offers a vapor barrier interior layer.¹⁴⁶ The HFD did not field test different types of hoods; however, several of the field notes indicated that the use of a Reed hood made scanning a room and using immediate action rapid deployment (IARD) techniques difficult because of the inability to rotate the neck.¹⁴⁷

3. Self-Contained Breathing Apparatus and Facepiece

Firefighters wear facepieces or masks in conjunction with SCBAs for respiratory protection from heat, smoke, hot toxic gases, and oxygen-deficient environments.¹⁴⁸ This piece of equipment allows the wearer to work in areas that would normally be untenable and immediately dangerous to life and health (IDLH).¹⁴⁹ The facepiece is constructed of a heat resistant polycarbonate. Before 2013, the facepiece was only required to withstand a five-minute oven test at 200°F, followed by exposure to 10 seconds of direct flame impingement.¹⁵⁰ In a 2011 study conducted by National Institute of Standards and Technology (NIST), “the cutoff point in lens exterior temperature for thermal degradation

¹⁴⁴ Dodson, *Firefighter's Handbook: Firefighting and Emergency Response*, 129.

¹⁴⁵ Ibid.

¹⁴⁶ Houston Fire Department, unpublished field notes, October 9, 2015.

¹⁴⁷ Ibid.

¹⁴⁸ Dodson, *Firefighter's Handbook: Firefighting and Emergency Response*, 143.

¹⁴⁹ Ibid.

¹⁵⁰ National Fire Protection Association, *NFPA 1981: Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*, 2013 ed. (Quincy, MA: National Fire Protections Association, 2013), 37.

of the facepiece was found to be between 200°C (392°F) and 250°C (482°F), which is consistent with the lower end of the polycarbonate melting temperature range.”¹⁵¹ However, in 2013, the NFPA standard was upgraded and new facepieces are now manufactured to maintain integrity at 500°F for five minutes in the oven test.¹⁵²

The SCBA consists of a compressed air bottle and a harness with valves, gauges, hoses, and regulators.¹⁵³ The compressed air bottle or cylinder can be constructed of aluminum, steel, or a carbon fiber composite; composite cylinders are lighter weight and composed of an aluminum alloy inner shell with a carbon-wrapped exterior.¹⁵⁴

In addition to the SCBAs designed for firefighters, several manufacturers produce stealth model SCBAs for law enforcement and military use. These SCBAs are designed to maintain concealment and are shrouded in black covers. Furthermore, all audible alarms and lights have been removed to facilitate concealment. However, neither the law enforcement and military model nor the firefighting model addresses the need to protect the compressed air cylinder from ballistics. This area will require future research. The HFD considered the SCBA an integral component for entry into a smoke-filled environment; protection of the respiratory tract and the inability to maintain an air supply within areas untenable in the absence of SCBAs were deemed mission critical, and therefore, the HFD elected to test the effects of ballistic impact to the air cylinder.¹⁵⁵

4. Gloves

Like turnout gear, structural firefighting gloves are designed to provide thermal and abrasion protection.¹⁵⁶ They are constructed with three layers: an exterior abrasion

¹⁵¹ Amy Mensch, George Braga, and Nelson Bryner, *NIST Technical Note 1724: Fire Exposures of Fire Fighter Self-Contained Breathing Apparatus Facepiece Lenses* (Gaithersburg, MD: Fire Research Division Engineering Laboratory National Institute of Standards and Technology, 2011), 29.

¹⁵² National Fire Protection Association, *NFPA 1981: Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*, 37.

¹⁵³ Dodson, *Firefighter's Handbook: Firefighting and Emergency Response*, 152.

¹⁵⁴ Scott Safety, *Cylinders, For Use with Scott Safety Self-Contained Breathing Apparatus* (Monroe, NC: Scott Safety, 2012), https://www.scottsafety.com/en/us/DocumentandMedia1/Bro_Cylinders_HS_7012_0312.pdf.

¹⁵⁵ Houston Fire Department, internal memo, August 3, 2015.

¹⁵⁶ Dodson, *Firefighter's Handbook: Firefighting and Emergency Response*, 129.

barrier (usually leather), a vapor barrier, and an internal thermal barrier.¹⁵⁷ Structural firefighter gloves are designed to withstand the rigors of interior structural firefighting repeatedly by providing protection against sharp debris and heat. However, their bulk limits manual dexterity, which is sacrificed in lieu of protection.¹⁵⁸ While this type of glove protects the firefighter, it is not suited for law enforcement personnel who require manual dexterity to handle a firearm.

Shooting gloves used by law enforcement officers are constructed of thin leather or synthetic materials that are not rated or treated for an incendiary environment; therefore, they will not protect the officers' hands in a fire. The glove must be thin enough to allow unimpeded manipulation of the trigger yet provide sufficient thermal protection to shield the wearer from contact burns from a hot weapon and radiant heat.¹⁵⁹ Neither bulky structural firefighting gloves nor thin law enforcement shooting gloves are suited for the entry team.

The HFD's research indicated the possibility that the military held the solution to this issue. Like firefighting gloves, flight gloves worn by fighter pilots must also withstand heat during a flash fire.¹⁶⁰ However, flight gloves must also be thin enough to allow the manual dexterity needed by the pilot. Some flight gloves are NFPA 1971 compliant, and therefore, are rated to provide thermal resistance. The HFD considered hand protection and weapon manipulation a fundamental requirement for mission success and chose to conduct field tests on gloves.¹⁶¹

5. Ballistic Protection

In addition to structural firefighter protective gear, the HFD incorporated technologies from other disciplines to protect responders from the dynamic threat environment. Their studies indicated that while not traditionally used in a fire

¹⁵⁷ Scott Safety, *Cylinders, For Use with Scott Safety Self-Contained Breathing Apparatus*.

¹⁵⁸ Dodson, *Firefighter's Handbook: Firefighting and Emergency Response*, 129.

¹⁵⁹ Houston Fire Department, internal memo, January 4, 2016.

¹⁶⁰ "DOD Flight Glove Specifications," MILDTL-81188C, accessed September 29, 2015, <http://every.spec.com/MIL-SPECS/MIL-SPECS-MIL-DTL/download.php?spec=MIL-DTL-81188C.041463.pdf>.

¹⁶¹ Houston Fire Department, internal memo, August 3, 2015.

environment, ballistic protection in the form of body armor could be worn under the firefighting protective ensemble.¹⁶² Body armor typically consists of front and rear panels, panel covers, and a carrier worn to provide ballistic protection to the torso.¹⁶³ Panels are designed to accommodate the shape of the wearer by coming in several shapes and sizes.¹⁶⁴ No type of body armor stops every threat; selection of the type to be worn depends on the threat the officers will face.¹⁶⁵

Soft body armor is flexible, daily wear armor designed to stop handguns and can be worn over or concealed under clothing. Soft armor is constructed of multiple layers of ballistic resistant material that distribute the force of the projectile by catching and deforming the round.¹⁶⁶ Hard armor offers greater protection from greater threats (rifle rounds) and is constructed of rigid material, such as ceramics, composites, metallic, or compressed laminate sheets.¹⁶⁷ Hard armor absorbs and distributes the energy in the round by either capturing or deforming the bullet or by breaking it apart.¹⁶⁸ An in-conjunction body assembly can be created when hard plates are added to soft armor to increase the protection level.¹⁶⁹ However, as weight is increased, the comfort and mobility of the wearer can decrease.

Firefighter turnout gear lacks ballistic protection; therefore, in a threat environment with firearms present, ballistic vests are essential to a protective entry team ensemble. The HFD was unable to locate reports describing the ability to combine ballistic vests with turnout gear, and therefore, elected to test the feasibility of combining

¹⁶² Houston Fire Department, internal memo, January 4, 2016.

¹⁶³ National Institute of Justice, *Guide to Body Armor, Application Guide 0101.06 to Ballistic-Resistant Body Armor* (Washington, DC: Department of Justice, 2014), 15.

¹⁶⁴ Ibid.

¹⁶⁵ Ibid., 21.

¹⁶⁶ Ibid., 15.

¹⁶⁷ Ibid.

¹⁶⁸ Ibid.

¹⁶⁹ Ibid., 7.

these protective articles.¹⁷⁰ Of concern were the effects of the additional weight on the performance and stamina of the operator.¹⁷¹

6. Thermal Imaging Cameras

During their field-testing, the HFD used handheld thermal imaging cameras since this piece of equipment is routinely used by Houston firefighters during response to low visibility environments. Thermal imaging cameras (TICs) were originally developed to provide soldiers with a tactical advantage by enabling them to see across dark, smoke-filled battlefields.¹⁷² This technology has been adapted to withstand the fire ground environment—with its housing constructed from heat and water-resistant, ruggedized materials—and has become an indispensable technological advance in the fire service. TICs work by converting infrared radiation to visible light that shows a heat picture of the scene; however, two objects at the same temperature will show as the same shade.¹⁷³

TICs used by firefighters are typically handheld devices, and while they provide firefighters with improved situational awareness, they cannot see through objects but rather detect the temperature differences on the surface of objects.¹⁷⁴ In addition, handheld TICs are cumbersome and occupy one of the operator's available hands. Helmet-mounted TICs, while less common, have the advantage of freeing the firefighter's hands to use other tools. Studies support several advantages of using helmet-mounted TICs over handheld TICs, "Teams of firefighters with helmet-mounted cameras completed search tasks substantially faster, were less disoriented, and used less air than teams with a single handheld camera, which in turn fared better than teams with no TIC at all."¹⁷⁵

¹⁷⁰ Houston Fire Department, internal memo, August 3, 2015.

¹⁷¹ Joo-Young Lee et al., "The Impact of Firefighter Personal Protective Equipment and Treadmill Protocol on Maximal Oxygen Uptake," *Journal of Occupational and Environmental Hygiene* 10, no. 7 (2013): 397. doi:10.1080/15459624.2013.792681.

¹⁷² "How a TI Works," accessed September 1, 2015, http://www.bullard.com/V3/products/thermal_imaging/how_a_ti_works.php.

¹⁷³ Jonathan Boyd, "Using Hands-Free Thermal Imaging Cameras," *Fire Engineering* 160, no. 5 (2007): 95–97.

¹⁷⁴ Ibid.

¹⁷⁵ Ibid.

Helmet-mounted TICs, however, do have limitations. In the monacle style TIC, depth perception is affected since they only provide a two-dimensional view, making it difficult to judge the distance of objects.¹⁷⁶ Again, objects with the same surface temperature will show up as the same shade, making it difficult to distinguish between the two when they are side by side. Additional limitations include increased cost and the need to train regularly since the wearer's eyes must adapt.¹⁷⁷ Until recently, this technology was only available in the United States as a monacle, allowing only one eye to see through the TIC while the other eye did not have enhanced vision. However, the latest helmet mounted TIC provides a small display on one side of the visual field in which the wearer can glance at the in mask display.¹⁷⁸ The limitations of this model result from the low quality of the image that makes it difficult to distinguish between objects.¹⁷⁹ The HFD's field tests did not assess the benefits and disadvantages of the various types of TICs; however, their field notes did reference the limitations to utilizing a handheld unit.¹⁸⁰

Houston's findings concluded that at a minimum, the initial entry team will need a PPE ensemble composed of elements traditionally worn by various first responders, but have not historically been worn together; firefighter structural PPE combined with ballistic vests typically used by law enforcement to protect against gunfire, flight gloves, and SCBAs.¹⁸¹

¹⁷⁶ Boyd, "Using Hands-Free Thermal Imaging Cameras," 95-97.

¹⁷⁷ Ibid.

¹⁷⁸ "Scott Sight," accessed May 19, 2016, <https://www.scottsafety.com/en/us/Pages/ProductDetail.aspx?productdetail=Scott+Sight>.

¹⁷⁹ Based on the author's direct experimentation and observation.

¹⁸⁰ Houston Fire Department, internal memo, January 4, 2016.

¹⁸¹ Ibid.

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V. HFD FIELD RESEARCH

This chapter explains the field tests conducted by the HFD from 2015–2016.¹⁸² Much of the information contained in this chapter was obtained from unpublished HFD field notes.¹⁸³ During their research, the HFD concluded that using a combination of traditional firefighting gear and tools, ballistic protection worn by police officers, and gloves that provide thermal protection and dexterity for firearms manipulation, will allow first responders to enter the hot zone effectively during a multi-threat environment involving ballistic and incendiary threats.¹⁸⁴ The HFD's analysis builds on the traditional firefighting PPE ensemble by suggesting modifications to the gloves and incorporating ballistic protection and helmet-mounted thermal imaging camera technologies in the context of a tactical firefighter entry team.

A. SELF-CONTAINED BREATHING APPARATUS

This section describes the purpose, methods and results of HFD's field testing of SCBAs. It evaluates their field testing and documents their decisions to design the field testing in the manner in which they did. Members of the HPD SWAT team and HPD bomb team collaborated with the HFD to document the effect of gunfire on SCBAs.¹⁸⁵ Specifically, the HFD was concerned with the possibility that the firefighters' compressed air cylinders would rupture if struck by projectiles, thereby, injuring the wearer, and ultimately, affecting mission success during a hostile event.¹⁸⁶

¹⁸² The information included in this chapter was obtained from direct experimentation that the author conducted. When applicable, reference is made to the unpublished documentation.

¹⁸³ Unpublished field notes and memos are public record and discoverable upon request from the Houston Fire Department through the Texas Public Information Act (TPIA).

¹⁸⁴ Houston Fire Department, internal memo, January 4, 2016.

¹⁸⁵ The information provided in this section was obtained from the Houston Fire Department from unpublished field notes, October 9, 2015.

¹⁸⁶ Houston Fire Department, internal memo, August 3, 2015.

1. Purpose

The purpose of this evaluation was to determine what would happen to a SCBA and the wearer if the compressed air tanks were struck. Scott SCBAs—the style worn by Houston firefighters—were tested to document the effects of various calibers of projectiles striking compressed air cylinders while worn by an operator. The SCBAs were subjected to different caliber rounds typically encountered by law enforcement in the Houston area. Personnel from the HPD SWAT team discharged the weapons while personnel from the HPD bomb team served as the safety officers and ensured that all attendees observed the testing from a safe location. Video surveillance equipment and photography were used to document the testing.

2. Method

On October 9, 2015, at 1000 hours, a series of tests was conducted at the Harris County Bomb Squad Range located at 2316 Atascocita Rd. in Humble, Texas in an open air field. A 10', wooden barricade with observation portals and dirt berms provided cover to observers posted. The tests were documented using a GoPro camera mounted on a stand five' south of the target and a high-definition video camera was staged 15' north of the target, allowing for high-definition, slow-motion video. Photographs were taken using a Nikon D5100 camera. The day was sunny but supplemental lighting in the form of flashlights and spotlights were used to illuminate the target for video quality enhancement.

Two props were constructed in-house in preparation for testing, a heavy duty, steel stand and a mannequin constructed from a fire hose. The first step was to construct a stand to support the mannequin and SCBA during the testing. The stand needed to be rugged enough to withstand repeated exposure to gunfire and sturdy enough to hold the mannequin and SCBA assembly consisting of a composite 4,500 psi cylinder weighing 19 pounds, and an aluminum Scott air pack harness weighing four pounds. A steel frame was welded together to provide the armature upon which the 190-pound mannequin and the SCBA with compressed air cylinder would be supported. The frame stood 5.5' high.

The second prop was a hose mannequin constructed using 2.5" x 50' decommissioned fire hoses, duct tape, steel weightlifting plates, and nuts and bolts. Every attempt was made to approximate the height and weight of an average American male. According to the latest CDC studies, an average American man weighs 195 pounds and stands 5'9" tall.¹⁸⁷ In total, the mannequin measured 6'6" in height and weighed 191 pounds. However, once placed on the stand, the mannequin settled under its own weight to stand 5'11." A Scott SCBA with a full air bottle was fitted on the mannequin and secured with the retention strap. The cylinder valve assembly was left in place; the regulator, hoses, gauges, PASS device and facepiece were not used during the tests.¹⁸⁸ Following each test sequence (six in total), the old air cylinder was removed and a new cylinder was used for each different weapon. The cartridges most commonly encountered by Houston police officers were used during the testing, rifle rounds included .308 and .223 cartridges. Buckshot (00) and slugs were used with the shotgun. The pistol rounds used were .45 auto, .40 S&W, and 9 mm Lugers.

3. Results

This section describes and reports HFD's results during the six field tests conducted using different calibers of ammunition. The weapons used were semi-automatic pistols, shotguns, and rifles. In addition, the damage caused by the various calibers of ammunition was recorded and evaluated.

a. Test 1: .223 Caliber Cartridges

The mannequin and stand were placed in the designated position and Remington 55 grain full metal jacket cartridges were used to shoot at a compressed air cylinder secured to the mannequin's air pack. The composite air cylinder was a 4,500 psi, 60-minute bottle, with a total air capacity of 2,464 liters.¹⁸⁹ The aluminum air pack harness

¹⁸⁷ "Body Measurement," accessed July 1, 2016, <http://www.cdc.gov/nchs/fastats/body-measurements.htm>.

¹⁸⁸ The Houston Fire Department's field notes indicated they were reluctant to leave the accessories in place out of concern that they would become lost or damaged during the field tests. Unpublished field notes, October 9, 2015.

¹⁸⁹ Scott Safety, *Cylinders, For Use with Scott Safety Self-Contained Breathing Apparatus*.

weighed four pounds and the full air cylinder weighed 19 pounds for a total weight of 23 pounds; the cylinder gauge read 4,100 psi.

A sniper was positioned 30 yards away from the mannequin and stand when he took the shot. When the projectile struck the cylinder, it created an entry point but not a point of exit. The projectile bounced inside the cylinder numerous times and damaged the interior of the air bottle. The slow motion video camera captured images of a small flame jetting out of the point of entry immediately following impact with the tank. Evidence of scorching to the cylinder was visible inside of the tank and at multiple points on the exterior of the tank. The .223 round did not propel the mannequin from the stand. The mannequin and stand did, however, fall forward as the air rushed out, and landed face down within 2' of its original placement. It took 48 seconds for all the air to escape.

b. Test 2: .308 Cartridges

A new air bottle was placed in the air pack frame and secured with the frame's retention strap. The mannequin, SCBA, and stand were returned to their designated placement. Federal Premium Gold Medal .308 Winchester cartridges were used to shoot the new 60-minute SCBA cylinder.¹⁹⁰ A SWAT sniper was positioned 60 yards from the target.¹⁹¹ Upon impact, the projectile penetrated the tank creating both entry and exit points. The round also went through the aluminum air pack frame and embedded itself approximately 1/2" deep within the hose. The mannequin was not propelled, but the force of the escaping compressed air was great enough to cause the cylinder to break the plastic retention strap buckle. The bottle freed itself from the air pack harness, and traveled upwards about 50' and a total of 242' before landing.

c. Test 3: Shotgun Ammunition

Since the retention strap buckle was broken during the previous test, a ratchet tie-down strap was used to hold the new 60-minute bottle in the air pack harness. A 4,500 psi

¹⁹⁰ Sierra Match King boat tail hollow point (BTHP) bullets, 168 grain. This information was obtained from Houston Fire Department field notes, October 9, 2015.

¹⁹¹ Both the safety officers and the sniper agreed to double the distance from the shooter to the target as a precaution. Houston Fire Department, unpublished field notes, October 9, 2015.

bottle was placed in the harness and shot with a shotgun loaded with Federal 00 buckshot. The shooter was positioned 20' away behind a ballistic shield and shot the tank five times but did not rupture or crack it. Air pressure readings were taken before and after the bottle was shot and none of the air escaped. The exterior of the tank displayed damage to the carbon fiber exterior where it was peppered by the projectiles. The bottle was left in place and was shot five times with a shotgun loaded with Remington 1-ounce slugs. On the fifth shot, the tank cracked and slowly released the compressed air during 248 seconds. Throughout this test, the mannequin remained positioned on the stand and did not move.

d. Test 4: .45 Auto Ammunition

A new 60-minute cylinder was placed in the air pack worn by the mannequin and was secured with the ratchet tie-down. This test used .45 auto Speer Lawman 230 grain full metal jacket ammunition.¹⁹² The shooter was positioned 20' west of the target, behind a ballistic shield, and discharged five rounds at the cylinder. The projectiles struck the cylinder and traveled along the curvature of the tank before stopping and embedding themselves within the fibers. In the process, some of the carbon fiber peeled off the tank along the bullets' trajectories; however, no loss of air was observed, nor any indication that the tank had ruptured.¹⁹³

e. Test 5: .40 S&W Ammunition

A new 60-minute cylinder was secured to the harness with the ratchet tie-down strap. This test used .40 S&W Speer Lawman 180 grain full metal jacket ammunition.¹⁹⁴ The cylinder contained 4,150 psi of air. The shooter was positioned 20' west of the target, behind a ballistic shield, and discharged five rounds at the cylinder. The projectiles struck the cylinder and traveled along the curvature of the tank. All the projectiles were observed to have embedded themselves within the composite fibers. In the process, the

¹⁹² Muzzle velocity of 830 feet/second and muzzle energy 352 foot pounds. Houston Fire Department, unpublished field notes, October 9, 2015.

¹⁹³ Houston Fire Department, unpublished field notes, October 9, 2015.

¹⁹⁴ Muzzle velocity of 985 feet/second and muzzle energy 388 foot pounds. Houston Fire Department, unpublished field notes.

carbon fiber peeled off the tank along the bullets' paths; however, no loss of air pressure was observed.

f. Test 6: 9 mm Luger

This test used 9 mm Luger Speer Lawman 124 grain full metal jacket ammunition.¹⁹⁵ A new air cylinder with 4,100 psi of air was secured in the harness using the ratchet tie-down strap. The shooter was positioned 20' west of the target, behind a ballistic shield, and discharged five rounds at the cylinder. The projectiles struck the cylinder and traveled along the curvature of the tank. In the process, the carbon fiber peeled off the tank along the bullets' trajectories; no loss of air was observed.

4. Evaluation

Pursuing an armed assailant is a dangerous and tactically complex situation compounded by the introduction of additional hazards, such as fire. While the use of firefighting PPE and SCBAs can protect a team from thermal injury, members of the entry team run the risk of having their air supply compromised if their tank becomes damaged from projectiles. The HFD's principle concerns centered on the risk of explosion of a tank damaged by gunfire or of propulsion of the wearer while still harnessed to the air pack and cylinder.¹⁹⁶ When forcefully struck or damaged by projectiles, none of the tanks exploded during the field tests; however, the two cylinders exposed to the largest caliber rounds sustained significant damage with a single shot leading to catastrophic failure within seconds.¹⁹⁷

a. .308 Cartridge

The .308 cartridge was the largest round used. Although none of the damaged cylinders propelled the mannequin through the air, the tank damaged by the .308 ammunition released the compressed air with sufficient force that it broke the buckle

¹⁹⁵ Muzzle velocity of 1090 feet/second and muzzle energy 327 foot pounds. Houston Fire Department, unpublished field notes.

¹⁹⁶ Houston Fire Department, internal memo, August 3, 2015.

¹⁹⁷ Houston Fire Department, unpublished field notes, October 9, 2015.

used to secure the air cylinder to the air pack harness. The .308 caliber round penetrated through both sides of the compressed air cylinder and lodged itself into the mannequin causing the quick release of all the air; however, only the tank became airborne and traveled a distance of 242' leaving the air pack frame and mannequin on the stand.¹⁹⁸

During the testing, the first two cylinders were secured to the harness with a retention strap and buckle, but were not coupled to the rubber pressure-reducer hose leading from the cylinder valve assembly to the regulator. It is unknown whether the force produced by depressurization would have been sufficient to dislodge the cylinder from the hose and coupling or whether the cylinder would have remained tethered via the hose despite the broken buckle. Regardless, the outcome would be catastrophic for the wearer. An out of control cylinder still tethered to the hose could repeatedly strike the wearer or anyone in close proximity. In addition, the rapid release of air will leave the wearer without an air supply in seconds. All the compressed air escaped within 48 seconds. The .308 cartridge proved to be the most dangerous and would likely be lethal.

b. .223 Cartridge

While the .223 ammunition did not propel the tank, the depressurization caused the stand and mannequin with SCBA to fall facedown approximately 2' from its original placement.¹⁹⁹ The .223 ammunition penetrated only one side of the cylinder and caused a slower depressurization of the SCBA than the .308 ammunition. The Remington .223 cartridge pierced the cylinder that created a point of entry but no exit. Although the air supply took longer to escape, the wearer would not have much time to exit the IDLH environment encountered during fires and locate breathable ambient air.²⁰⁰ An additional complication involved the heat transfer of the projectile to the tank and air supply.

¹⁹⁸ Houston Fire Department, unpublished field notes, October 9, 2015.

¹⁹⁹ Ibid.

²⁰⁰ Immediately Dangerous to Life or Health (IDLH) is defined by the Occupational Safety and Health Administration (OSHA) as "an atmosphere that poses an immediate threat to life, would cause irreversible adverse health effects, or would impair an individual's ability to escape from a dangerous atmosphere," "Section 7—VII. Summary and Explanation," January 8, 1998, https://www.osha.gov/pls/oshaweb/owa_disp.show_document?p_id=1053&p_table=PREAMBLES.

Scorching was clearly visible inside the cylinder.²⁰¹ The heat transferred through to the exterior carbon fiber where more scorching and heat damage was visible. In addition to the short time frame in which all the air was lost, the air available during those 48 seconds may have been heated and could cause thermal damage to the operator's respiratory tract.

c. *Shotgun: 00 Buckshot and Slugs*

It took five rounds of shotgun slugs to crack the SCBA tank causing a slow air release that lasted several minutes. The shotgun slugs cracked the tank but did not pierce the tank that allowed the compressed air to leak out slowly over the course of 2.5 minutes.²⁰² In an IDLH environment with a compromised ambient air supply, an extremely short amount of time to find breathable air will affect the ability of an entry team to complete its mission. The 00 Buckshot did not cause a catastrophic failure by compromising the integrity of the tank or adversely impacting the wearer's air supply.

d. *Semi-automatic Pistol Cartridges*

None of the handgun ammunition damaged the tank to the point of causing air to escape. None of the ammunition fired from the handguns penetrated or damaged the integrity of the air cylinder.²⁰³ However, gunfire from handguns could potentially ricochet from the tank and injure the entry team.

B. GLOVES

This section describes the purpose, methods, and results of HFD's field testing of different types of gloves. It evaluates their field testing and documents their decisions to design the field testing in the manner in which they did. The gloves were evaluated for thermal resistance and dexterity.

²⁰¹ This observation was noted in the October 9, 2015 unpublished Houston Fire Department field notes and resulted from participation in direct experimentation by the author.

²⁰² Houston Fire Department, unpublished field notes, October 9, 2015.

²⁰³ Ibid.

1. Purpose

The HFD evaluated two styles of gloves under live fire (incendiary) conditions to assess whether gloves could permit the wearer to manipulate and discharge a firearm while maintaining adequate thermal protection. Department-issued structural firefighting gloves and thermal resistant flight gloves used by pilots were tested. The flight gloves were specifically selected because of their fire resistance ratings.²⁰⁴

2. Method

Both styles of gloves underwent two field tests that took place at two different venues. The first field test assessed the thermal protection of the gloves during a timed evolution. This assessment occurred at the fire training facility and incorporated the use of an external heat source. The second field test assessed the ability of the operator to draw a holstered firearm while wearing gloves; although the firearms were not loaded, the evolution occurred at a law enforcement bomb and firing range. Each participant for these field tests held state commissions in firefighting and in law enforcement.

The first field test happened on August 10, 2015 at the HFD's training facility located at 8030 Braniff in Houston, Texas, within the department's live fire training structure ("burn building").²⁰⁵ Weather conditions were hot and sunny (temperature in shade: 98°F, temperature: 102°F, heat index: 104°F) with 95% humidity. The participants wore HFD-issued turnout gear and Scott SCBA packs (60-minute bottles containing 4,100 psi air), and carried hand-held thermal imaging cameras able to take temperature readings. Three wooden pallets and hay were ignited using a natural gas feed in the designated first floor burn chamber to create hot, smoky conditions. Temperature readings were recorded throughout the exercise using TICs. Within five minutes of ignition in the burn chamber room, the floor temperature reading was recorded at 105°F

²⁰⁴ The flight gloves meet the following standards and regulations. "Orion Glove," accessed October 3, 2015, https://www.wileyx.com/pdf/SpecSheets/ORION_Glove.pdf.

²⁰⁵ The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, August 10, 2015.

and the ceiling temperature was 300°F.²⁰⁶ Fifteen minutes later, the floor temperature had increased to 150°F where it remained for the remainder of the 20-minute evolution; the ceiling temperature remained at 500°F.

Participants donned full firefighting PPE with SCBAs (60-minute bottles at 4,100 psi) and thermal imaging cameras. Participant #1 wore department issued leather structural firefighting gloves; participant #2 wore flight gloves. The participants remained within 3' of one another throughout the exercise. While breathing tank air, both participants entered the building simultaneously and proceeded to the room containing the burn chamber. The participants exited the building and remained outside for 15 minutes to allow the equipment to cool. The participants exchanged gloves and re-entered the burn building simultaneously for another 20-minute evolution.²⁰⁷

The second field test was conducted on August 11, 2015, at the Harris County Bomb Squad Range located at 2316 Atascocita Rd in Humble, Texas.²⁰⁸ The purpose of this field test was to assess manual dexterity while wearing different glove styles to determine whether a holstered handgun could be drawn and fired. The two gloves tested were the structural firefighting gloves and flight gloves used during field test #1. The participants wore HFD issued structural firefighting gloves and drew holstered handguns (unloaded). Next, they located the trigger to fire the weapon. Finally, they accessed the magazine release button and loaded a new magazine (unloaded) into the weapon. The manual dexterity evolution was repeated using flight gloves and the results were documented.

3. Results

The results of the two field tests conducted are recorded in the following sections. Each section briefly describes HFD's results. The section concludes with an evaluation of the field testing.

²⁰⁶ The burn building at the training complex has 12' ceilings. Houston Fire Department, unpublished field notes, August 10, 2015.

²⁰⁷ Houston Fire Department, unpublished field notes, August 10, 2015.

²⁰⁸ The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, August 11, 2015.

a. Test 1: Thermal Resistance

Within 10 minutes of beginning the evolution, participant #1 documented discomfort and overheating in both hands while wearing the structural firefighting gloves and resorted to shielding the gloved hands away from the heat source; the temperature was recorded at a point on the wall 3' above ground level to be 230°F.²⁰⁹ Participant #2 recorded a similar outcome at the 10-minute mark while wearing the structural firefighting gloves. Within 10 minutes of wearing the flight gloves, participant #1 did not feel thermal discomfort in either hand. At the 15-minute mark, participant #1 documented the feeling of heat to both hands but did not feel pain. While wearing the flight gloves, participant #2 documented the sensation of heat, but no discomfort within 10 minutes of the evolution.²¹⁰

b. Test 2: Dexterity

During the first evolution, the structural firefighting gloves were used. The field notes indicated difficulty and clumsiness in manipulating the weapon and when unholstering. Neither participant was able to access the trigger due to the bulk of the heavy leather gloves, which prevented them from getting past the trigger guard. The notes and evidence reveal difficulty in releasing empty magazines and reloading the weapon with a second magazine. The participants relied on the second hand to guide the weapon back into the holster.

While wearing the flight gloves, the field notes indicated the officers were able to draw their holstered weapon and access the trigger without difficulty. The notes also indicated they did not struggle to access the magazine release button and were able to reload a new magazine. In addition, the participants were able to holster the handgun without using the second hand to guide the weapon into the holster.

²⁰⁹ Houston Fire Department, unpublished field notes, August 11, 2015.

²¹⁰ Ibid.

4. Evaluation

The field notes indicated the flight gloves used during the evolution protected the hands from heat equally well or better than the firefighting gloves. In addition, the flight gloves permitted the drawing of holstered weapons and magazine changes without difficulty; those using the structural firefighting gloves struggled to complete the evolution. Finally, re-holstering the weapon with one hand was easier with the flight gloves than with the structural firefighting gloves.

C. BALLISTIC VESTS AND TURNOUT GEAR

To protect first responders from a fire combined with an armed active assailant, responders will require protective equipment suited to the multiple threat environment. The HFD conducted field testing to evaluate the feasibility of wearing body armor in conjunction with structural firefighting bunker gear and a SCBA ensemble. This section describes the purpose, methods and results of HFD's field testing of different ballistic vests worn in conjunction with structural firefighter bunker gear. It evaluates their field testing and documents their decisions to design the field testing in the manner in which they did.

1. Purpose

The purpose of these field tests was to assess the ability of personnel to wear ballistic protection in conjunction with full firefighter PPE. According to the National Institute of Justice (NIJ), body armor is classified based on its level of ballistic resistance.²¹¹ A corresponding increase in weight occurs with increased levels of ballistic protection; however, additional weight in the form of a ballistic vest was a key consideration since greater weight leads to faster fatigue of personnel.²¹² Other factors considered during the evaluation were the overall comfort of the vest when worn in combination with the firefighting ensemble and the possibility of overheating the wearer.

²¹¹ National Institute of Justice, "Body Armor Performance Standards," accessed October 1, 2015, <http://www.nij.gov/topics/technology/body-armor/pages/standards.aspx>.

²¹² Lee et al., "The Impact of Firefighter Personal Protective Equipment and Treadmill Protocol on Maximal Oxygen Uptake."

2. Method

The HFD conducted field tests using ballistic vests offering varying levels of ballistic protection: Level II, Level III, and Level IV. Department issued structural firefighting bunker gear was used (pants, coat, boots, helmet, hood, gloves, facepiece, and SCBA). Given that the testing combined the protective gear of the fire service and law enforcement, the HFD utilized firefighters who were state certified as both Texas peace officers and as firefighters with a minimum of seven years of field experience in each discipline.²¹³ For each test, the subjects donned identical ballistic vests and documented comfort level, maneuverability, and fatigue during live fire conditions. The first two trials utilized the same two participants, but only one of those participants was available for the third trial. The trials were held on three different days but at the same venue. The field tests took place at the HFD's training facility located at 8030 Braniff, in Houston, Texas, in the department's live fire training structure ("burn building").

Three wooden pallets were ignited using a natural gas feed in the designated first floor burn chamber. Temperature readings were taken throughout the exercises using thermal imaging cameras. In addition to body armor, each subject donned department issued bunker pants, coats, boots, hood hoods, gloves, helmets, SCBAs with a mask, a clip-on light, a radio, 9 mm blue guns, and a thermal imaging camera. The subjects remained on tank air during each evolution and each subject cycled through two 60-minute bottles. Temperature readings were assessed with a TIC and reported every 10 minutes by a safety officer.

During the first two evolutions, a two-person team, wearing full protective gear and breathing tank air, entered the structure and worked their way through the building, clearing rooms using IARD techniques. Continuous communication and activity was maintained throughout. When one of the team member's low air warning alerted, both teammates exited the building and received new air bottles. Once the new air bottles were secured to the SCBA, the team entered the building and resumed clearing rooms until one of the team member's low air warning alerted and the team exited the building,

²¹³ The participants were members of Houston Fire Department's Arson Bureau. Houston Fire Department, unpublished field notes, August 10, 2015.

concluding the evolution. During the third evolution, one of the team members was unavailable to participate, but the HFD proceeded with the evolution using a single officer entry unit. The same evolution was conducted with the exception of the loss of a team member.

3. Results

This section reports the results of HFD's field testing of Level II, III, and IV body armor while worn with structural firefighter PPE. The information was obtained from HFD unpublished field notes. The findings are followed by an evaluation of HFD's field testing and the significance of their results.

a. Test #1: Firefighter PPE, SCBA, and Level II Body Armor²¹⁴

On October 2, 2015, members of the HFD documented the results of the first PPE ensemble evolution.²¹⁵ Level II vests were worn beneath the bunker gear.²¹⁶ At the 10-minute mark, the floor temperature was recorded at 114°F and the ceiling temperature was recorded at 460°F.²¹⁷ The air bottles used during the evolution contained 4,100 psi of air.

Level II vests are soft (flexible) body armor capable of protecting against various handguns.²¹⁸ The field notes indicated the Level II vest did not cause any observable level of discomfort during the evolution.²¹⁹ The vest was flexible enough to allow unrestricted movement and was not noticeable when worn with the firefighting gear. The notes reported the vest did not impede full expansion during exertion and did not produce thermal discomfort. The participants remained in the building for 24 minutes, received a

²¹⁴ The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, October 2, 2015.

²¹⁵ Houston Fire Department, unpublished field notes, October 2, 2015.

²¹⁶ The vest weighed 3.5 pounds. Houston Fire Department, unpublished field notes, October 2, 2015.

²¹⁷ The ceiling height was 12 feet. Houston Fire Department, unpublished field notes, October 2, 2015.

²¹⁸ National Institute of Justice, "Body Armor Performance Standards"; Level II armor is rated to protect against .22LR cartridges, .380 ACP, 9mm, and .40 S&W.

²¹⁹ Houston Fire Department, unpublished field notes, October 2, 2015.

replacement air bottle, and worked for an additional 20 minutes (for a total of 44 minutes of searching). They exited when alerted by the low air warning.

The field notes documented concerns with other aspects of the protective ensemble.²²⁰ While the handheld TIC afforded the ability to see through smoke, allowing the efficient clearing of a room with low visibility, using the handheld TIC left only one hand to handle the firearm. The handheld TIC also became heavy as the evolution proceeded, contributing to less frequent use. The personal alert safety system (PASS device) integrated into the SCBAs alerted several times during the evolution when the team stood still for 30 seconds or more, causing them to stop what they were doing to silence the alarm. The team adapted by rocking in place or bouncing on their toes to fool the PASS device.²²¹ The team reported that the style of hood restricted their head movement to such an extent that they had to pivot at the waist or shuffle their feet to scan rooms and to maintain situational awareness. A final concern of the participants involved the reflective material on the bunker gear. It is an NFA requirement; however, the field notes stated that when illuminated with a light or by flames, the reflective material became visible through the smoke and made concealment more difficult.

b. Test #2: Firefighter PPE, SCBA, and Level III Body Armor²²²

On November 14, 2015, members of the HFD conducted the second PPE trial.²²³ Level III stand-alone vests with a front and back 10" x 12" polyethylene shooter's cut plate were worn beneath the bunker gear.²²⁴ Temperature readings were assessed with a TIC and reported every 10 minutes. The four air bottles (two for each team member) used during the evolution contained 4,100 psi.²²⁵ The same participants in Test #1 were used

²²⁰ The information provided in this section was obtained from the Houston Fire Department from unpublished field notes, October 2, 2015.

²²¹ Houston Fire Department, unpublished field notes, October 2, 2015.

²²² The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, November 14, 2015.

²²³ Ibid.

²²⁴ The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, November 14, 2015. The body armor weighed 7.8 pounds and consisted of two plates and a plate carrier.

²²⁵ Houston Fire Department, unpublished field notes, November 14, 2015.

in Test #2. The Level III vests weighed 7.8 pounds and were four pounds heavier than the Level II vest. In addition, the Level II vests were bulkier; the poly plates were each about 1” thick and added about 2” of girth. The field notes indicated that when the team members donned their bunker coats, they could not secure the buttons and d-rings. The team was provided larger coats and finished dressing out. The notes indicated the team did not have difficulty breathing and neither overheated nor felt fatigued. The evolution lasted a total of 39 minutes. The first round of bottles was replaced after 22 minutes of work and the second round lasted 17 minutes.

The field notes again cited the same issues with the cumbersome nature of the handheld TIC, the difficulty in scanning a room while wearing the rigid hood, the loss of concealment due to the reflective surface of the bunker gear, and the need to move constantly because of the PASS alert.²²⁶

c. Test #3: Firefighter PPE, SCBA, and Level IV Body Armor²²⁷

On November 17, 2015, members of the HFD conducted the third PPE trial.²²⁸ Only one of the team members participated in this evolution and wore a Level IV 10’ x 12’ shooter’s cut ceramic chest plate in conjunction with IIIA soft armor vest under bunker gear.²²⁹ Temperature readings were assessed with a TIC and reported every 10 minutes. During the evolution, the first air bottle lasted 19 minutes and the second bottle lasted 12 minutes. The notes indicated the participant voluntarily terminated the evolution with 1,800 psi remaining in the tank.²³⁰ The notes indicated that overheating and fatigue were factors in the termination of the evolution. The field notes once again cited the same

²²⁶ The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, November 14, 2015.

²²⁷ Ibid.

²²⁸ The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, November 17, 2015.

²²⁹ The local SWAT team used this body armor. The plate was a composite of alumina ceramic/aramid. The vest weighed 18 pounds and did not include neck, groin, or deltoid protection. “Hard Body Armor,” 2016, <http://www.pointblankenterprises.com/paraclete/wp-content/uploads/sites/2/2016/04/Hard-Armor-2016-10046-Product-Sheet.pdf>.

²³⁰ The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, November 17, 2015.

issues with the cumbersome nature of the handheld TIC, the difficulty in scanning a room while wearing the rigid hood, the loss of concealment due to the reflective surface of the bunker gear, and the need to move constantly because of the PASS alert.²³¹

4. Evaluation

Based on HFD's fieldwork, the following conclusions were made. The Level II vest produced the least amount of strain on the participants. This result was not surprising given that the Level II vest weighed the least (3.5 pounds), was thin, and flexible. While wearing the Level II vest, the participants reported no impact on their performance within the heated environment nor struggled to complete the evolution.²³² Of the three vests evaluated, however, the Level II vest offered the least amount of protection against ballistics. It is used by law enforcement personnel as concealable general patrol duty protective equipment able to stop handgun rounds. Level II is not considered sufficient protection for pursuing active shooters and will not protect the wearer from rifle rounds, .357, or .44 Magnum cartridges.²³³

The Level IV plate on the vest provided the greatest amount of protection against ballistics. Level IV vests are rated to stop large (30–06) armor piercing rounds; however, that level of protection comes at the price of more weight. The vest tested weighed 18 pounds; five times the weight of the Level II vest and twice as much as the Level III vest (7.8 pounds). The field notes documented a marked difference while wearing the Level IV vest.²³⁴ Further contributing to the discomfort with the gear combination was the complication that occurred when the bunker coat and SCBA were donned. As they settled, they pulled on the ballistic vest, causing it to slide back in such a way that the participant's neck was slightly constricted by the collar area of the vest. As the evolution continued, the equipment continued to settle and the pressure of the vest against the neck

²³¹ The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, November 17, 2015.

²³² Houston Fire Department, unpublished field notes, October 2, 2015.

²³³ National Institute of Justice, "Body Armor Performance Standards."

²³⁴ Houston Fire Department, unpublished field notes, November 14, 2015; Houston Fire Department, unpublished field notes, November 17, 2015.

increased to the point that the team member compensated by maintaining the neck muscles flexed.²³⁵

The Level III vest, weighing at 7.8 pounds, reportedly had less of an adverse performance impact than the Level IV vest, yet is able to provide protection against rifle rounds, such as the .308 and .223.²³⁶ While using this vest resulted in increased bulk, requiring larger bunker coats, the level of discomfort was reported to be manageable by the team members. However, endurance appeared to be affected.²³⁷ The team used the air supply in the cylinders at a faster rate while wearing the Level III vest than the Level II.

In addition to documenting exercise performance with the vest and firefighting PPE ensemble, the field notes also provided insight related to other pieces of equipment carried.²³⁸ The use of a TIC only allowed team members the use of one hand for the firearm, which is an area of concern. While the handheld TIC provided a tactical advantage for target acquisition and situational awareness within low visibility environments, it was described as cumbersome and heavy. The teams attempted to compensate by clipping the TIC to their SCBAs to allow two hands for weapon manipulation, but still had to release the weapon with their weak hand to point the TIC when scanning.²³⁹

The field notes consistently reported that the style of hood used with the ensemble felt restrictive and did not allow participants to move their neck to scan a room. Consequently, the team had to pivot at the waist or shuffle their feet and move their entire bodies to look around the room when searching.²⁴⁰ An alternative to the Reed style

²³⁵ Houston Fire Department, unpublished field notes, November 17, 2015.

²³⁶ National Institute of Justice, "Body Armor Performance Standards."

²³⁷ Houston Fire Department, unpublished field notes, October 2, 2015; Houston Fire Department, unpublished field notes, November 14, 2015; Houston Fire Department, unpublished field notes, November 17, 2015.

²³⁸ The information provided in this section was obtained from the Houston Fire Department, unpublished field notes, November 17, 2015.

²³⁹ Houston Fire Department, unpublished field notes, October 2, 2015; Houston Fire Department, unpublished field notes, November 14, 2015; Houston Fire Department, unpublished field notes, November 17, 2015.

²⁴⁰ This observation was obtained through direct experimentation of the author.

hood used could be a knit hood that provides for greater range of motion but offers less thermal protection.

Another documented issue concerned the reflective material on the bunker gear. Whenever a light shined on the material, it reflected the light and made concealment difficult.²⁴¹ The field notes raised concerns that teams would be too visible to an assailant even through the smoke.²⁴² In addition, the audible alarms on the SCBAs presented challenges. The alarms automatically alert when a firefighter is in distress and stops moving for 30 seconds or more.²⁴³ Law enforcement personnel may need to stand still for more than 30 seconds, triggering the alarms, which emit sounds in excess of 95 decibels, and flashing lights.²⁴⁴ While these lights and alarms are necessary for a firefighting environment, they could impact the mission success of a multi-disciplinary team with the shared goals of trying to control a fire while simultaneously seeking armed assailants.

D. LESSONS LEARNED BY THE HFD²⁴⁵

While working toward developing its tactical firefighter team, the HFD began with the question: Is it realistic or feasible to equip an entry team across fire and police disciplines in such a way that they are protected from thermal injury and from gunfire yet agile enough to rescue victims, contain and extinguish fire, and neutralize shooters?

To answer that question, the HFD conducted various field tests of protective equipment to assess the efficacy of combining first responder gear not traditionally worn together. The HFD documented the effects of discharging firearms of different calibers at compressed air cylinders used in self-contained breathing apparatus. They also explored whether flight gloves could provide sufficient manual dexterity and thermal protection to a law enforcement officer exposed to a fire and heat while deploying a firearm. Lastly,

²⁴¹ This observation was obtained through direct experimentation of the author.

²⁴² Houston Fire Department, unpublished field notes, November 17, 2015.

²⁴³ National Fire Protection Association, *NFPA 1981: Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*.

²⁴⁴ Ibid.

²⁴⁵ The information provided in this section was obtained from a Houston Fire Department internal memo, January 4, 2016.

the HFD assessed the ability of an operator wearing firefighting PPE and ballistic protection to meet mission objectives within an environment with combined fire and ballistic threats. As a result of their field tests, several lessons were learned, unexpected results were documented, and additional questions emerged.

1. Finding #1: The 190 Pound Mannequin Was Not Propelled through the Air²⁴⁶

The researchers originally expected the mannequin to be propelled several feet from the stand; however, that was not the case. Since they were initially unsure of the damage that would be inflicted on the air packs, the researchers deliberately removed the hoses, gauges, and regulators normally connected to the cylinder. What was not expected was that the escaping air would produce sufficient force to break the air pack's retention strap and that the cylinder would travel such a great distance (80 yards). Future researchers should consider field-testing the air pack in its entirety—including the hoses, couplings, and facepiece—to determine whether tethering the tank to the air pack would produce any change in outcome.

2. Finding #2: The SCBA Cylinder Did Not Explode when Struck by Ammunition²⁴⁷

When struck by projectiles, none of the SCBA cylinders exploded; however, several of the rounds did damage the cylinder and caused the air to escape. In the HFD's field tests, handgun cartridges did not appear to damage the integrity of the SCBA bottle and cause an air release or loss of breathable air; however, the handgun projectiles struck the bottles and traveled along the curvature of the cylinders before slowing and becoming embedded in the composite fibers of the exterior wrapping. The long guns produced varying degrees of structural damage to the cylinders. While it took five shots with a shotgun slug to crack the tank and slowly release the air, the damage caused by the .223 caliber cartridge, used in assault rifles, was devastating. The projectile carried sufficient force to puncture the tank, allowing the air supply to escape quickly, leaving the wearer

²⁴⁶ Houston Fire Department, unpublished field notes, October 9, 2015.

²⁴⁷ Ibid.

without breathable air within a minute. In addition, evidence of scorching throughout the inside of the tank indicated that combustion was sustained for an unknown amount of time. Further research is needed to assess whether the heat transfer to the air supply could damage the wearer's lungs. The .308 caliber round also immediately caused catastrophic damage to the tank and led to air loss within less than one minute. It was the only round tested with sufficient force to penetrate both sides of the air cylinder and continue approximately 1/2" into the mannequin. The air from the cylinder escaped within a few seconds and caused the tank to detach itself from the mannequin. Consequently, impact to the SCBA with this round would be immediately catastrophic to an operator even in the presence of adequate body armor (Level III or IV) since there would be insufficient time to locate an alternative source of breathable air.

3. Finding #3: Protective Equipment Must Work as a Cohesive Ensemble²⁴⁸

The HFD field tests highlighted the importance of combining protective gear across disciplines. The HFD's findings support the use of Level II and Level III vests in combination with firefighting PPE. The Level IV vest, while effective gunfire protection, did not allow for heat dissipation and overheated the operator. Of the three types of vests field tested, only the Level IV caused fatigue and overheating to such an extent that the participant voluntarily terminated the evolution. No observable thermal burden was evident with a Level II vest, but it does not provide ballistic protection against long guns.²⁴⁹ According to HFD's field notes, the Level III vest provides protection from rifles and allowed the operators to sustain operations in pursuit of an assailant.²⁵⁰

Several unanticipated outcomes resulted when the vest and bunker gear were worn together. One of the most disconcerting events occurred when a ballistic vest settled

²⁴⁸ Houston Fire Department, unpublished field notes, August 10, 2015; Houston Fire Department; unpublished field notes, August 11, 2015; Houston Fire Department, unpublished field notes, October 2, 2015; Houston Fire Department, unpublished field notes, October 9, 2015; Houston Fire Department, unpublished field notes, November 14, 2015; Houston Fire Department, unpublished field notes, November 17, 2015.

²⁴⁹ National Institute of Justice, *Selection and Application Guide to Ballistic-Resistant Body Armor for Law Enforcement, Corrections and Public Safety* (Washington, DC: Department of Justice, 2014).

²⁵⁰ Houston Fire Department, internal memo, January 4, 2016.

and slid backwards after the bunker coat and air pack had been donned by the operator, causing pressure on the operator's neck.²⁵¹ Continued movement exacerbated the airway constriction, and once inside the burn building and performing the evolution, the operator was no longer in a position to make equipment adjustments. This finding suggests that the ballistic vest needs to be fitted and adjusted properly to the operator so that it does not shift or slide when worn with other gear. However, the vest must still allow room for adequate chest expansion during times of exertion and for heat dissipation. The bunker coat also needs to be sized slightly larger to allow for the bulk of the ballistic plates.²⁵²

The HFD also raised concerns regarding the ability of law enforcement officers to provide force protection to firefighters in the heated space, typically encountered during building fires, in which ambient temperatures could exceed the human body's ability to tolerate burns. According to NIST, humans begin to feel pain when exposed to heat at 111°F; however, human skin can actually sustain burns at 109°F when exposed to that temperature for several hours.²⁵³ Exposure to 118°F results in immediate first-degree burns. At 131°F, second-degree burns are sustained. Third-degree burns are sustained within five seconds of exposure to 140°F. Given the human body's relatively low threshold to tolerate burns, law enforcement personnel are extremely limited in their ability to enter the fire environment without specialized firefighting PPE (bunker gear, structural firefighting gloves, and SCBAs).

In addition to protecting the wearer from thermal injury, firefighting gloves are designed to provide protection from abrasion, cuts, and penetrating trauma due to the debris encountered in structure fires; consequently, they are often constructed of thick rugged materials like leather.²⁵⁴ That level of protection, however, comes at a price principally in the form of lost manual dexterity and fine motor movement. The loss of that ability is unfortunately catastrophic to a law enforcement officer who relies on

²⁵¹ Houston Fire Department, internal memo, November 17, 2016.

²⁵² Ibid.

²⁵³ "Fire Dynamics," accessed May 25, 2016, http://www.nist.gov/fire/fire_behavior.cfm?o=37981&l=dir&qsrc=990&qo=contentPageRelatedSearch&ad=SEO&ap=search.yahoo.com&an=SEO.

²⁵⁴ Dodson, *Firefighter's Handbook: Firefighting and Emergency Response*, 129.

dexterity and fine motor movement to manipulate the firearm. In addition, officers must often rely on feel since their visual field is focused on maintaining situational awareness and target acquisition.

While the officer needs the thermal protection afforded by fire gloves and not provided by tactical shooting gloves, the officer does not require the protection from cuts and penetrating trauma that can result from fire debris, breaching, and handling fire hoses. At a minimum, protection of the police officers' hands is of vital importance since any injury or discomfort to them can adversely impact an officer's ability to use a firearm, consequently impacting the ability to execute the tactical mission. Law enforcement tactical shooting gloves are not designed for the hot firefighting environment and provide inadequate thermal protection. Providing police officers with firefighting gloves is not a viable option since their bulky nature impedes the police officer's ability to manipulate and shoot a firearm effectively. Given that neither firefighter gloves nor law enforcement gloves could provide the necessary thermal barrier, yet allow for manual dexterity, the HFD looked for alternative gloves used in other industries. They hypothesized that gloves designed for pilots could be used for entry into the fire environment if they were rated to withstand flash fires.²⁵⁵ The HFD tested two types of gloves (department issue structural firefighting gloves and fire rated flight gloves) in an effort to find a style that could provide both thermal protection and manual dexterity to those handling weapons. Reportedly, the flight gloves handled the heat, as well as the firefighting gloves and allowed for weapon manipulation.²⁵⁶ The HFD's field test appears to support the use of thermal-rated flight gloves for use by law enforcement personnel in a heated environment.

The HFD's field testing indicated that flight gloves with thermal resistance ratings have the potential to provide law enforcement personnel with the ability to operate their firearms effectively in a hot environment while providing protection to the officer's hands. However, the functionality of flight gloves is limited since they are not sufficiently ruggedized to protect the wearer from sharp objects. The advantages of

²⁵⁵ Houston Fire Department, internal memo, August 3, 2015.

²⁵⁶ Houston Fire Department, unpublished field notes, August 10, 2015.

leather gloves lie in their ability to withstand the repeated physical abuse encountered when pulling hoses, and manipulate sharp and edged objects. A tactical entry team will need both types of gloves to allow moving from one task to another.

The Reed hood was found to be too rigid and detrimental to law enforcement objectives because it impeded the ability to rotate the head for scanning the room.²⁵⁷ The Reed hood is constructed of the same material used in bunker gear (Kevlar) and provides the chemical barrier that the HFD desires; however, it limits the wearer's ability to move the neck from side to side. An alternative would be to use the more flexible knit hood that provides thermal protection yet allows a greater range of motion of the neck. The main advantage to the knit hood is that it is constructed of a flexible fire resistant fiber (Nomex blend) providing the ability to rotate the neck.²⁵⁸ Further study is required on the practicality of one style hood over the other, particularly for law enforcement personnel who need to find assailants within a structure.

In addition, the fire service's NFPA requirements for audible alarms, warning lights, and reflective materials on their protective equipment create concealment difficulties for law enforcement and could adversely impact the team's safety by revealing its whereabouts to an assailant.²⁵⁹ Alternative law enforcement SCBA models should be considered to address the need for concealment, and consideration should be given to the removal of the reflective material on the bunker gear.

²⁵⁷ Houston Fire Department, unpublished field notes, November 14, 2015; Houston Fire Department, unpublished field notes, November 17, 2015.

²⁵⁸ Homeland Security Studies and Analysis Institute, *Project Responder 4: 2014 National Technology Plan for Emergency Response to Catastrophic Incidents* (Washington, DC: Department of Homeland Security, 2014), https://www.dhs.gov/sites/default/files/publications/Project%20Responder%2004_1.pdf.

²⁵⁹ National Fire Protection Association, National Fire Protection Association, *NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*; National Fire Protection Association, National Fire Protection Association, *NFPA 1981: Standard on Open-Circuit Self-Contained Breathing Apparatus (SCBA) for Emergency Services*."

4. Finding #4: Handheld Thermal Imaging Cameras Are Inadequate²⁶⁰

The field testing also revealed additional equipment needs that had not initially been anticipated. First responders rely on thermal imaging cameras to see within low visibility environments. A law enforcement officer relies on vision for target acquisition. In a low visibility, smoky environment, thermal imaging cameras are the only means of seeing inside the structure; however, when one of the operator's hands is dedicated to holding the thermal imaging camera, only one hand is available to handle the firearm. In the future, a hands-free thermal imaging camera needs to be evaluated to determine whether it provides the desired situational awareness. A periodic review of technological advances should be conducted, since augmented reality built into the firefighting facepiece is in development and could offer a better solution in the near future.

E. SUMMARY

Complex, multifaceted threats will require not only a cross-disciplinary incident response by first responders, but will also require the first responder to be equipped across disciplines. The equipment and weapons worn by the team will need to be appropriate to the environment to protect the responders and provide them with a tactical advantage. However, the various elements that comprise first responder protective equipment are often developed and tested in isolation from each other. To optimize the functionality and performance of protective equipment, a systems or modular approach is required.²⁶¹ The HFD's findings support the cross-equipping of an entry team for a mixed threat environment by creating a PPE ensemble composed of elements traditionally worn by various first responders but have not historically been worn together. This team will need firefighter structural PPE combined with ballistic vests typically used by law enforcement to protect against rifle rounds. Gloves are a part of the firefighting ensemble; however, to accommodate the threat encountered, a set of flight gloves can be added to

²⁶⁰ Houston Fire Department, unpublished field notes, October 2, 2015; Houston Fire Department, unpublished field notes, November 14, 2015; Houston Fire Department, unpublished field notes, November 17, 2015.

²⁶¹ Homeland Security Studies and Analysis Institute, *Project Responder 4: 2014 National Technology Plan for Emergency Response to Catastrophic Incidents*, 101.

the ensemble to allow the team to adapt between fighting fire and firing weapons. Additionally, tools, such as thermal imagers, will provide the team with a tactical advantage within a low visibility environment. Although the weight of the bunker gear will increase slightly due to the addition of the ballistic vest, it did not create such a burden as to inhibit the ability of the team to operate.

VI. CONCLUSION AND RECOMMENDATIONS

A. INTRODUCTION

Complex hostile events and paramilitary terrorist assaults go by many names: Mumbai attack, hybrid targeted violence, multiple modality attack, and complex active shooter assault. Emergency management experts Shahrzad Rizvi and Joshua Kelly contend that “attacks such as the Westgate Mall attack in 2013, the 2014 Peshawar school massacre in Pakistan, and the 2015 attack on the Charlie Hebdo office in Paris serve to remind us that Mumbai-style attacks are the new normal for terrorists.”²⁶² Unlike the typical American active shooter event, paramilitary assaults around the world often result in high casualty and high wounding rates.²⁶³ They involve a combination of tactics that overwhelm first responders and delay the response by requiring the integration of multiple first responder strategies to mitigate the incident.²⁶⁴ In addition to shooting, this type of attack typically incorporates other tactics, such as hostage taking, IEDs, or fire to attract media coverage and overwhelm the emergency responders.²⁶⁵ “Planning and weapons proficiency are distinctive features of the attack.”²⁶⁶ Furthermore, the assailants seek to engage law enforcement in battle without stopping to negotiate.²⁶⁷ These incidents are among the most dangerous that first responders will encounter during their careers. Multiple hazards are simultaneously in play and often lead to unpredictable outcomes, as was evident when the twin towers collapsed at the World Trade Center on 9/11. According to the NIST study, it was not the impact of the aircraft that caused the buildings to collapse, it was the structural failure induced by prolonged exposure to

²⁶² Rizvi and Kelly, “The Continued Relevance of the November 2008 Mumbai Terrorist Attack: Countering New Attacks with Old Lessons.”

²⁶³ New York Police Department Intelligence Division, *Mumbai Attack Analysis* (New York: New York Police Department Intelligence Division, 2008).

²⁶⁴ Ibid.

²⁶⁵ Angel Rabasa et al., *The Lessons of Mumbai* (Santa Monica, CA: RAND Corporation, 2009).

²⁶⁶ Rizvi and Kelly, “The Continued Relevance of the November 2008 Mumbai Terrorist Attack: Countering New Attacks with Old Lessons.”

²⁶⁷ *Terrorists Can Think Strategically: Lessons Learned from the Mumbai Attacks, Testimony presented before the Senate Homeland Security and Governmental Affairs Committee* (2009) (Brian Michael Jenkins).

fire.²⁶⁸ To mitigate these emergencies and increase the survival of the victims, the first responder community must actively develop the capability to respond within a dynamic and austere threat environment involving the use of fire as a weapon or delay tactic.²⁶⁹ This attack style is designed to overwhelm local resources through its unpredictability and speed; therefore, an effective response by public safety personnel will need to be equally flexible and adaptive.

This thesis examined the need for and utilization of tactical firefighter teams in the U.S. fire service to assist law enforcement during hostile events requiring combined fire and police skill sets to mitigate the incident. The merits and limitations of different tactical fire team models currently in use in the United States were presented. The latest assaults have witnessed an emerging trend where the goal of the assailants is to kill as many people as possible. With little intention of negotiation by the attackers, hostages have become doomed captives whose only chance of survival is the swift action by public safety personnel.²⁷⁰

Some of the earliest attempts at creating cross-disciplinary teams involved the embedding of firefighters within SWAT teams to assist with medical interventions or firefighting support during the incident. Agencies, such as the Palm Bay Fire Department, Clayton County (GA) Fire and Emergency Services, LFRA use a SWAT-Tactical Medic and SWAT-Tactical Firefighter model to respond to hostile events. The benefit of this model is the tactical expertise developed by a small cadre of select firefighters through monthly training and annual testing with the SWAT team. The limitations of this model involve the extended response time when the team is off-duty and must be recalled. Potentially, during incidents in which hostages are exposed to fire and smoke, there may be insufficient time to mobilize a SWAT response. While the LFRA does not arm its

²⁶⁸ “NIST WTC 7 Investigation Finds Building Fire Caused Collapse,” August 21, 2008, http://www.nist.gov/public_affairs/releases/wtc-082108.cfm.

²⁶⁹ Ibid.

²⁷⁰ Ahmed S. Hashim, *Cities under Siege: Mass Casualty Urban Terrorism Assaults* (Singapore: Nanyang Technological University S. Rajaratnam School of International Studies, 2016), 5, http://www.rsis.edu.sg/wp-content/uploads/2016/05/PR160505_Cities-under-Siege.pdf; Natasha Bertrand and Pamela Engel, “The FBI Director Painted a Bizarre Picture of the Man Behind the Worst Mass Shooting in U.S. History,” *Business Insider*, June 13, 2016, <http://www.businessinsider.com/james-comey-orlando-shooting-omar-mateen-fbi-2016-6>.

SWAT firefighters, Palm Bay and Clayton County have deputized them when they function in a medical capacity.²⁷¹ However, weapons are not allowed during firefighting activities.

The Charlotte Fire Department has implemented a tactical fire team specifically trained to link up with SWAT and other law enforcement personnel at hostile events. This team does not wear ballistic protection and is designed to only advance into the warm zone while SWAT provides them armed protection. They too are limited in their ability to engage in an interior fire attack under direct threat. In contrast, the FDNY has not developed a special operations tactical firefighter team but has instead implemented a rescue task force model in which any one of 11,000 firefighters can link up with any of NYPD's 35,000 officers to conduct warm zone operations. This model provides a rapid response capability; however, the firefighters receive neither ballistic protection nor specialized tactical law enforcement training. Since these models limit the entry of firefighters to warm zone operations, hostages located within areas of direct threat in which smoke and fire are present will be inaccessible to rescuers allowing assailants ample time to "(i) kill as many people as they are able to; (ii) gain as much media mileage of their butchery; and (iii) highlight government ineptitude."²⁷²

To address this response gap, the HFD explored ways of introducing fire personnel into hot zones or direct threat operations by field testing adaptations to the protection ensembles worn by firefighters and police officers. Their findings support the concept of combining ballistic vests with structural firefighting bunker gear to engage in interior fire suppression during hostile events. The HFD model also proposed combining law enforcement rapid deployment tactics with firefighting tactics and the introduction of armed public safety personnel into areas where fire and smoke are present, however, this area needs further research and analysis particularly with respect to the effects of heat on live ammunition.

²⁷¹ "Palm Bay Adds Six Paramedics to SWAT Team," October 1, 2012, <http://spacecoastdaily.com/2012/10/palm-bay-adds-six-paramedics-to-swat-team/>.

²⁷² Hashim, *Cities Under Siege: Mass Casualty Urban Terrorism Assaults*, 3.

B. RECOMMENDATIONS

This thesis recommends the implementation of a tiered deployment model for tactical fire teams responding to hostile events.²⁷³ Tiered EMS deployment services have proven advantageous in large urban jurisdictions in which the entire department is trained to handle routine incidents and specialists receive additional training and equipment to address incidents with the greatest complexity.²⁷⁴ This same rationale is used for the development of special operations teams, such as urban search and rescue units and HazMat response teams. A tiered model will allow for scalability and can provide jurisdictions with the capacity to respond to multiple hostile events of varying degrees in complexity.

1. Develop Rescue Task Force Capabilities for All Emergency Response Personnel

The rescue task force model implemented by the FDNY ensures rapid response to hostile events during the earliest stages. These units provide a large pool of personnel for less tactically complex tasks that still require firefighting skill sets. By combining with available police officers, these teams can provide fire, rescue, and EMS support within warm zones.

2. Incorporate Charlotte Fire Department's and Loveland Fire Rescue Authority's Models to Assist Law Enforcement Personnel

Researchers have demonstrated that tactically complex tasks and complex motor skills require repetitive training to ingrain movement into the motor memory when under extreme stress.²⁷⁵ Chaotic unstable environments can increase stress reactions that further

²⁷³ Jack Stout, Paul E. Pepe, and Vincent N. Mosesso, Jr., "All-Advanced Life Support vs Tiered-Response Ambulance Systems," *Prehospital Emergency Care: Official Journal of the National Association of EMS Physicians and the National Association of State EMS Directors* 4, no. 1 (2000): 1–6, <http://www.ncbi.nlm.nih.gov/pubmed/10634274>.

²⁷⁴ Thomas H. Blackwell and Jay S. Kaufman, "Response Time Effectiveness: Comparison of Response Time and Survival in an Urban Emergency Medical Services System," *Academic Emergency Medicine: Official Journal of the Society for Academic Emergency Medicine* 9, no. 4 (2002): 288–295. doi:10.1197/aemj.9.4.288.

²⁷⁵ Richard A. Schmidt and Craig A. Wrisberg, *Motor Learning and Performance: A Situation-Based Learning Approach*, 4th ed. (Champaign, IL: Human Kinetics, 2008), 7.

contribute to the obstacles the operators must overcome. Designate specific personnel at fire stations to receive tactical training for incorporation into SWAT teams to support breaching activities, chemical, biological, radiological, nuclear and explosives (CBRNE) response, and gross decontamination during hostile events to include instances of civil unrest. Although these teams will be limited to warm zone operation, they will serve as a force multiplier especially when multiple venues are involved and resources will be spread throughout the area.

3. Develop Special Operations Team for Response to Hostile Events

This thesis builds on existing tactical fire team models and offers an additional solution that takes advantage of the HFD's arson investigation division. Commissioned by the State of Texas as firefighters and as peace officers, this workforce is trained in tactics for firefighting and policing and has the additional awareness of the challenges and limitations experienced across disciplines. With experience in fighting fire and experience as law enforcement officers, members of the arson unit are uniquely situated to respond as either a strike team capable of fire suppression, law enforcement rapid deployment to neutralize armed assault, or as a force multiplier to augment the efforts of existing rescue task forces during hostile events.

This thesis does not advocate for the creation of a consolidated police and fire agency in which personnel are tasked with both law enforcement patrol duties and firefighting duties, but instead, seeks to deploy an existing, underutilized asset on an as-needed basis.²⁷⁶ The HFD currently employs 70 full-time arson investigators who provide 24/7 coverage within the City of Houston.²⁷⁷ Every investigator began their career in the department as a firefighter and possesses a minimum of five years of service. Once promoted into the HFD Arson Bureau, investigators train at a six-month police academy and are later certified as peace officers in the State of Texas.²⁷⁸ Upon graduation, arson investigators are assigned to determine the origin and cause of fires and

²⁷⁶ Vinicio R. Mata, "The Contribution of Police and Fire Consolidation to the Homeland Security Mission" (master's thesis, Naval Postgraduate School, 2010), 64.

²⁷⁷ Houston Fire Department, internal memo, January 4, 2016.

²⁷⁸ Ibid.

to conduct criminal investigations for fire related felonies. As police officers, trained to expect violent resistance from suspects, they execute high-risk warrants for a variety of felonies ranging from arson to murder.²⁷⁹ Despite their cross-disciplinary experience, little effort has been made to incorporate this group into Houston's homeland security endeavors simply because their primary job duties transitioned from emergency response to investigations. It should be noted that while this work is applicable to Houston, not all fire departments across the United States maintain full-time arson squads that have been certified as state peace officers.

Arson investigators are typically committed to non-emergency, investigative tasks and could be deployed on an emergency basis when warranted. New tactics will need to be developed, as well as scenario-based exercises, to maintain the operational capacity of a team that will only respond to low frequency, high-risk events. Firefighting, breaching, tactical team movement, and weapons proficiency are perishable skills that necessitate repetitive training. However, responding to hostile events will require advanced skill sets with operators who can improvise when tactics or equipment fail. First units to enter must be autonomous and cross disciplined since unknown threats can be encountered. The role of this special operations team would be to disentangle the threats sufficiently to allow traditional firefighting units to continue extinguishing the fire and traditional law enforcement units to continue searching for assailants. According to HFD's analysis, "minimal departmental costs would be incurred for periodic scenario-based training and drilling. Investigators currently have turnout gear and body armor; however, an initial startup cost would involve upgrading ballistic vests to use more expensive lightweight rifle plates."²⁸⁰

C. FUTURE RESEARCH

This thesis focused, in part, on the protective equipment needs of tactical fire teams for hot zone entry. However, the research did not address the effects of heat and fire to firearms and ammunitions. It is not uncommon for boxed ammunition to be

²⁷⁹ Houston Fire Department, internal memo, January 4, 2016.

²⁸⁰ Ibid.

encountered within structure fires. A 2012 ATF study documented the behavior of boxed ammunition in a compartment fire; however, it did not address whether ammunition loaded in weapons will react and auto-ignite at the same temperatures as boxed ammunition. The study discovered that when the cartridges reached temperatures ranging from 385°F to 529°F, ammunition will detonate and the round will travel several feet even when stored in its original boxed packaging.²⁸¹ The ambient temperature in the compartment, however, was much higher than the temperature that needed to be absorbed by the propellant and primer, ranging from 585°F to 703°F. Temperature is an important detail since firefighting SCBA face masks are subject to failure at temperatures ranging from 250°F to 500°F.²⁸² Potentially, it could mean that the limiting factor in withstanding heat is the capability of the facepiece and not of the ammunition.

Research is also needed in the development of combined law enforcement and firefighting tactics within an incendiary environment. For example, awareness of thermodynamics could be used strategically both to protect hostages and neutralize assailants. Additionally, future studies are needed to examine the thermal effects on firearms and projectile trajectories.

D. CONCLUSION

To remain relevant, the fire service must periodically reassess the needs of the community it protects to create new strategies and tactics to meet those demands.²⁸³ While suppressing fires remains a core capability, threats with a terrorist nexus have emerged and need to be embraced as a core competency. One of the challenges facing the fire service will be the acceptance of calculated risks in areas historically considered traditional police environments. Arguments against deployment of fire and EMS personnel into a police hot zone center on the notion of acceptable risk for firefighters. In a recent *Homeland Security Affairs* article, Marino et al. explained that the “concept of

²⁸¹ James Panos, *Behavior of Ammunition in a Compartment Fire* (Seattle, WA: Bureau of Alcohol, Tobacco, Firearms, and Explosives Seattle Field Division, 2012), 45.

²⁸² National Fire Protection Association, *NFPA 1971: Standard on Protective Ensembles for Structural Fire Fighting and Proximity Fire Fighting*.

²⁸³ Douglas M. Weeks, “Strategic Changes for the Fire Service in the Post 9/11 Era” (master’s thesis, Naval Postgraduate School, 2007), 77.

scene safety is one that is ingrained in all fire and EMS personnel from the earliest stages of training.”²⁸⁴ While firefighters are comfortable entering incendiary environments, the police hot zone may pose too great a risk for fire and EMS responders to assume.²⁸⁵ Fire chiefs across the United States have made it clear they will not implement an approach, such as Moody proposes, to authorize emergency response personnel to enter an environment where shots are being fired, even with ballistic protection; at most, they will allow fire and EMS personnel to enter the warm zones while escorted by police.²⁸⁶ However, when the lives of victims are jeopardized, public safety officials increasingly find themselves in positions where standard operating procedures are inadequate to address the changing threat environment.²⁸⁷

Public safety organizations have a critical need to establish strategies for response to tactically complex hostile events with combined law enforcement and firefighting missions. This thesis presented the merits and limitations of different models regarding the role of firefighters during a paramilitary attack. The specific circumstances encountered during an emergency will dictate the most appropriate team to mitigate the crisis. Given Houston’s unique needs and resources, this thesis offered a fourth model for consideration and proposed the use of combat firefighting units staffed by on-duty arson investigators capable of entry into the hot zone. This option challenges the traditional roles and duties of emergency response personnel and serves to continue the dialogue.

The tactical firefighter model is not to be viewed as a panacea but as an additional resource for the fire department in the event of a paramilitary attack. Sean Newman’s research demonstrated that “what is consistently absent from law enforcement preparations for a Mumbai-type terrorist event is the consideration of fire as part of the

²⁸⁴ Marino et al., “To Save Lives and Property: High Threat Response.”

²⁸⁵ Ibid.

²⁸⁶ International Association of Fire Chiefs, *Active Shooter and Mass Casualty Terrorist Events* International Association of Fire Chiefs.

²⁸⁷ “Shooting during Phoenix House Fire,” February 23, 2016, <http://www.firefighternation.com/article/news-2/shooting-during-phoenix-house-fire>.

weapons mix.”²⁸⁸ This same lack of preparation is evident on the fire department side as well. By failing to consider the possibility of this type of assault, the responsibility of developing response strategies is left to the on-duty personnel who have little or no preparation to meet the demands of a rapidly unfolding paramilitary attack. The recommendation to deploy arson squad assets to terrorist attacks increases the capability of the HFD by providing additional skill sets from a workforce that has not historically been used in an emergency response setting. While it is not feasible to anticipate and develop responses to every single crisis, it is possible to increase the department’s capabilities to allow for greater adaptability in the midst of chaotic events.

²⁸⁸ Newman, “Braving the Swarm: Lowering Anticipated Group Bias in Integrated Fire/Police Units Facing Paramilitary Terrorism,” 37.

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